US008522814B2

(12) **United States Patent**
Kempf et al.

(10) **Patent No.: US 8,522,814 B2**
(45) **Date of Patent: Sep. 3, 2013**

(54) **WATER CONTROL VALVE ASSEMBLY**

(75) Inventors: **Dale Kempf**, Clovis, CA (US); **Ken Lum**, Fresno, CA (US)

(73) Assignee: **Grundfos Pumps Corporation**, Olathe, KS (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 17 days.

(21) Appl. No.: **12/426,635**

(22) Filed: **Apr. 20, 2009**

(65) **Prior Publication Data**

US 2009/0230200 A1 Sep. 17, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/702,743, filed on Feb. 5, 2007, now abandoned, which is a continuation of application No. 10/832,492, filed on Apr. 27, 2004, now Pat. No. 7,198,059, which is a continuation-in-part of application No. 10/394,795, filed on Mar. 21, 2003, now Pat. No. 7,073,528, which is a continuation-in-part of application No. 10/006,970, filed on Dec. 4, 2001, now Pat. No. 6,929,187, which is a continuation-in-part of application No. 09/697,520, filed on Oct. 25, 2000, now Pat. No. 6,536,464.

(60) Provisional application No. 60/465,854, filed on Apr. 28, 2003.

(51) **Int. Cl.**
F16K 49/00 (2006.01)

(52) **U.S. Cl.**
USPC **137/337**; 137/468; 236/12.1

(58) **Field of Classification Search**
USPC 137/337, 468; 236/12.1, 12.13
See application file for complete search history.

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6,257,493 B1	7/2001	Chamot et al.		

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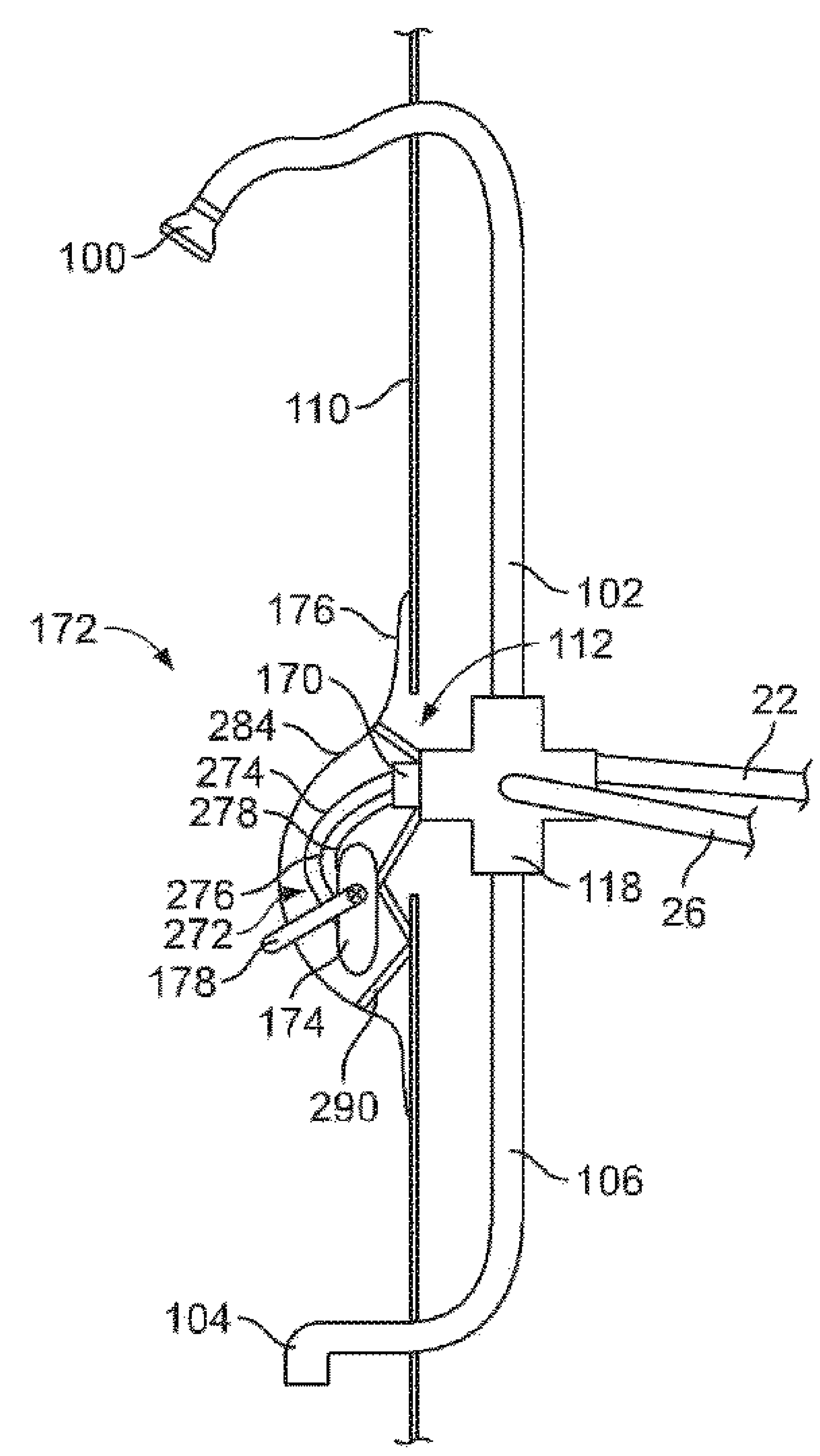
Primary Examiner — Kevin Lee
Assistant Examiner — Macade Brown
(74) *Attorney, Agent, or Firm* — The Small Patent Law Group, LLC

(57) **ABSTRACT**

A water control valve assembly includes a valve manifold having a mixing chamber for mixing water from a supply of hot water and a supply of cold water. The valve manifold has a water control element controlling the flow of water from the mixing chamber to a discharge port of the valve manifold. A thermostatically controlled bypass valve is in fluid communication with the valve manifold, wherein the bypass valve is configured to bypass water from the supply of hot water to the supply of cold water.

24 Claims, 32 Drawing Sheets



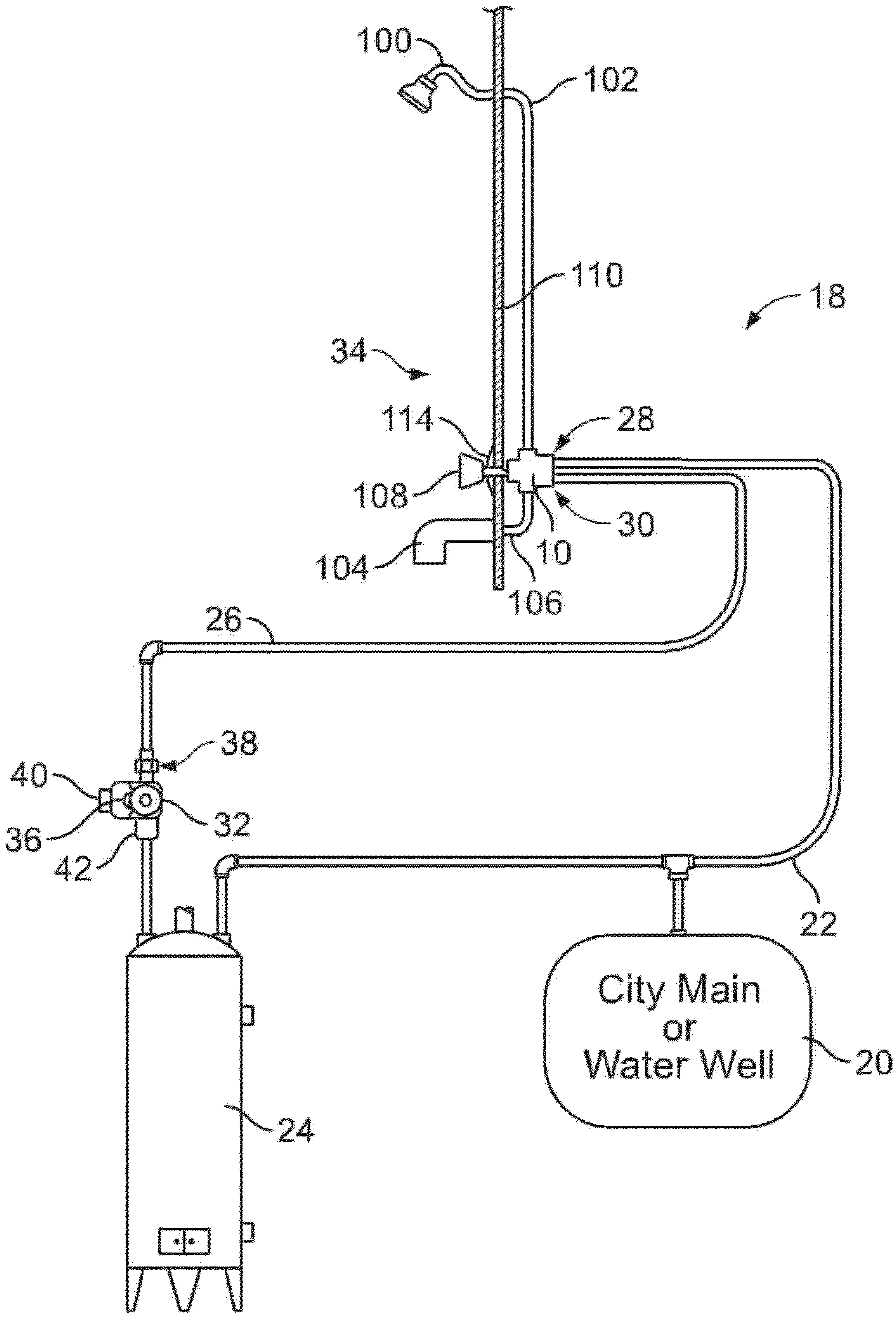


FIG. 1
(Prior Art)

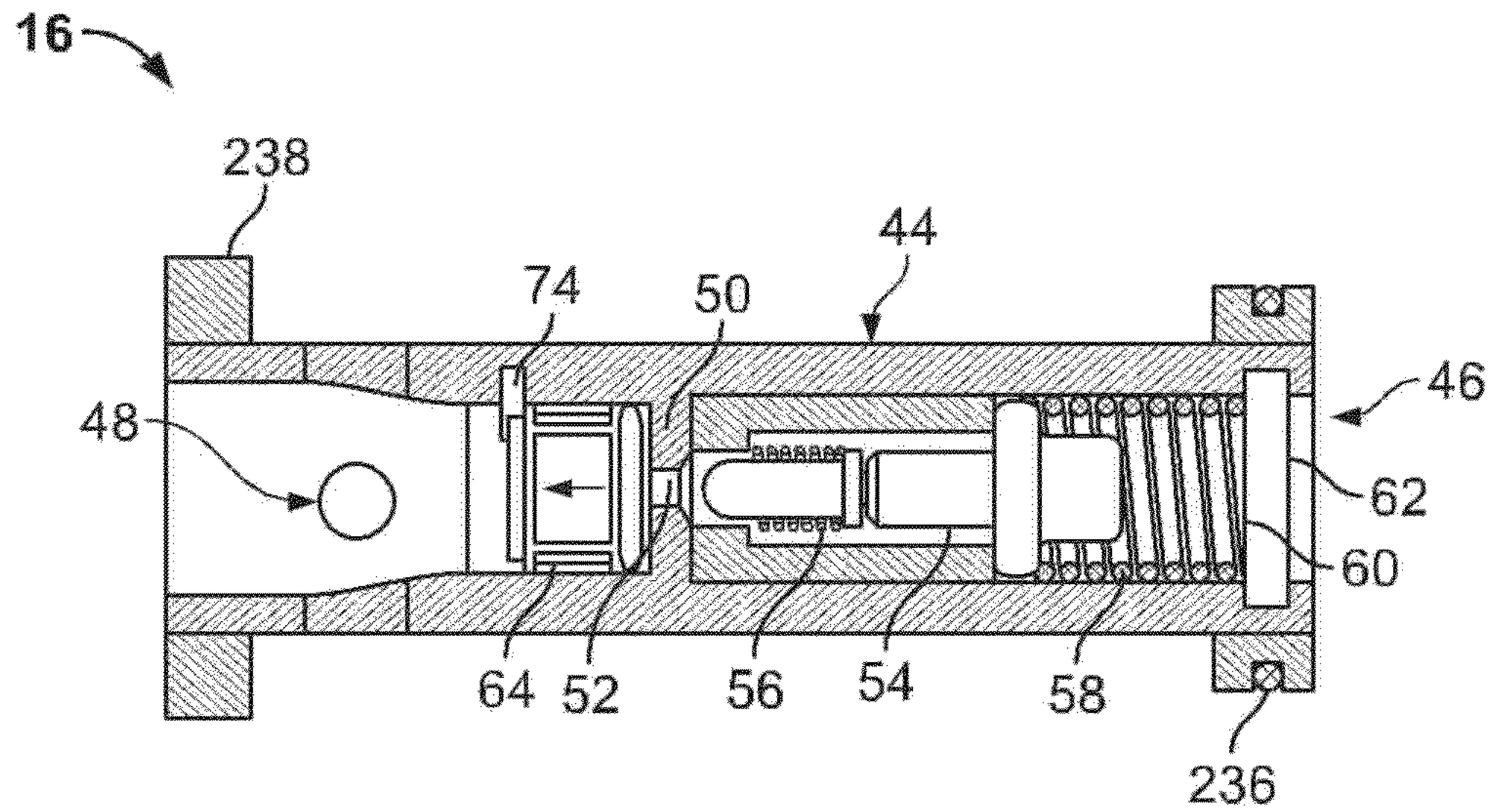


FIG. 2

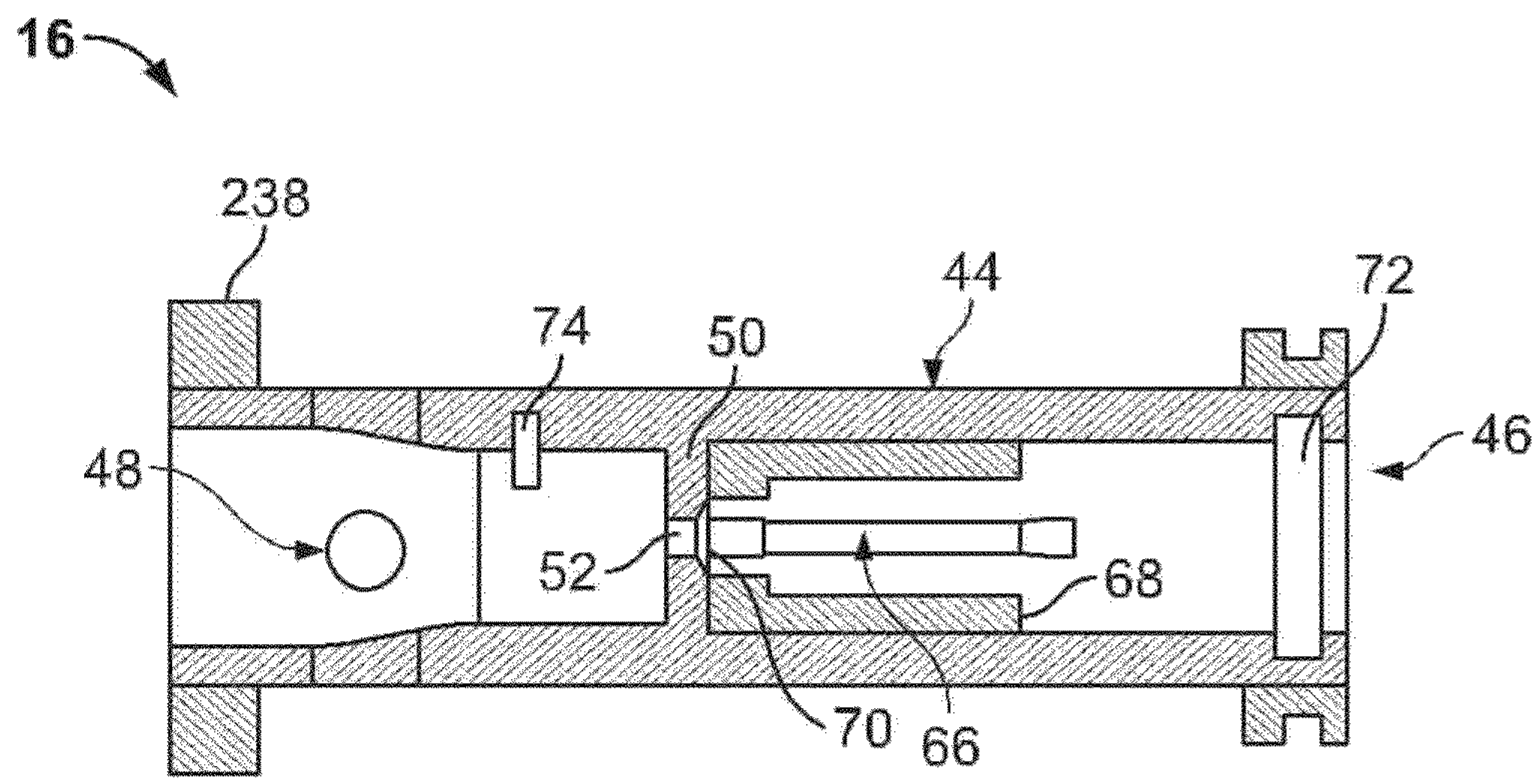


FIG. 3

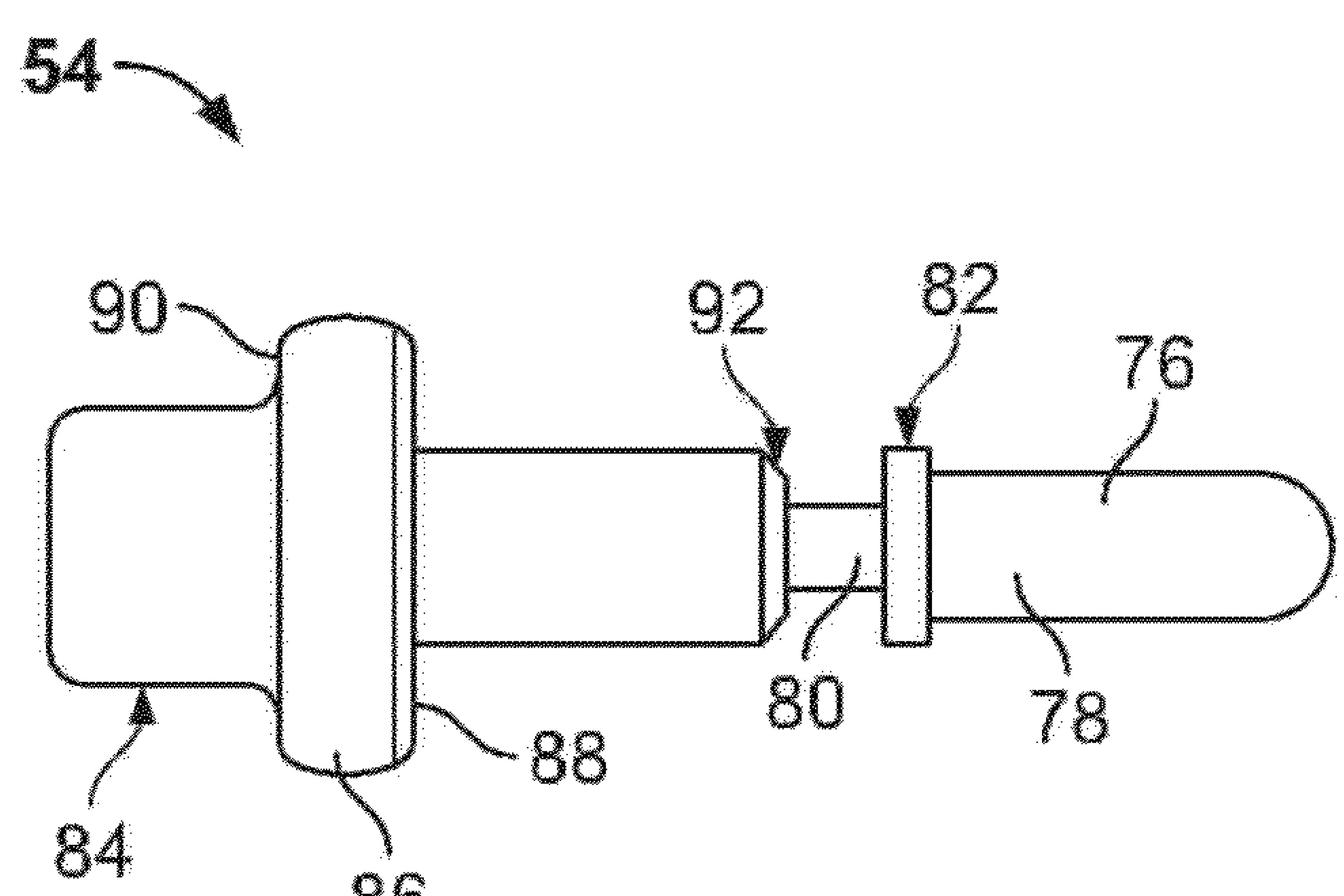


FIG. 4

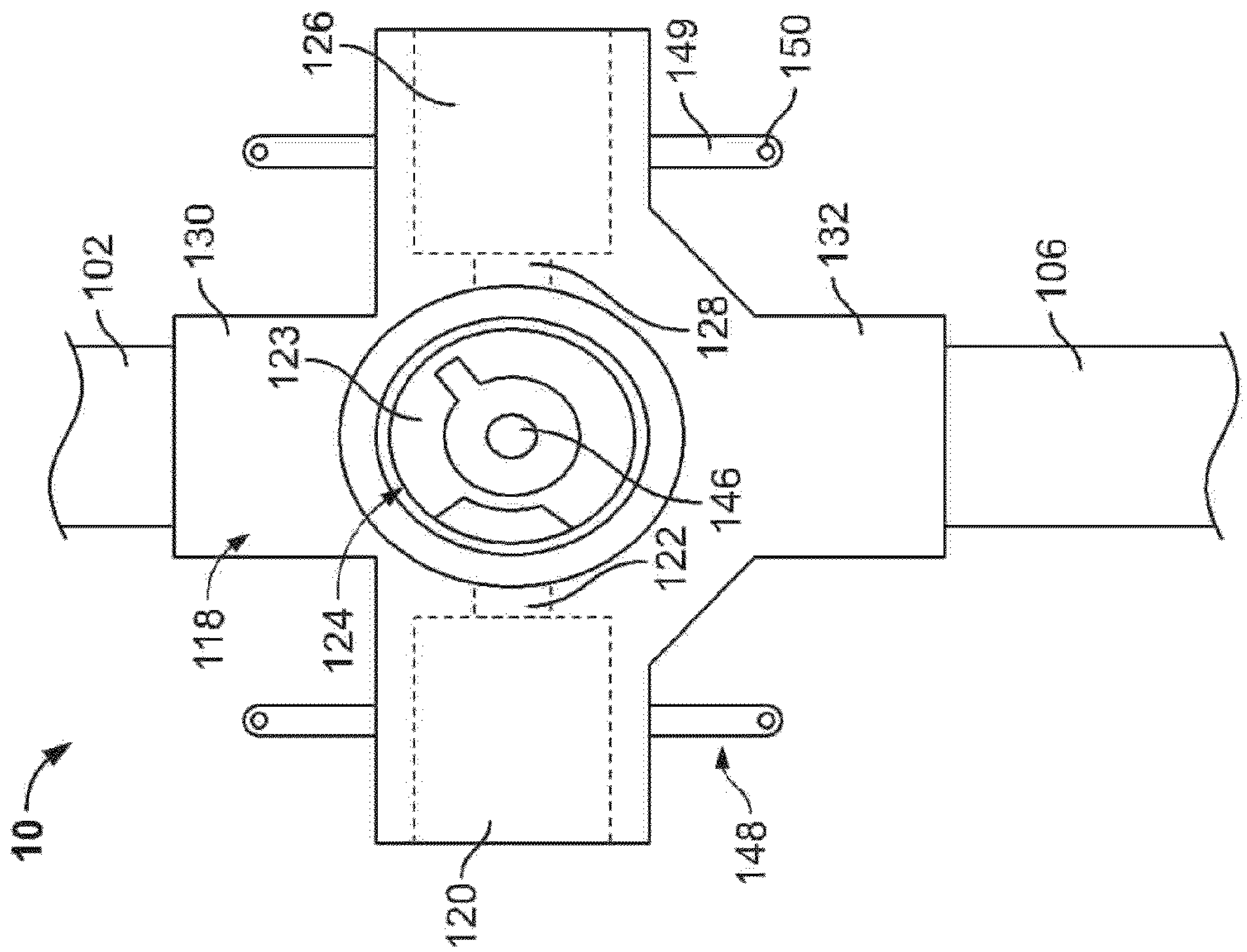


FIG. 5
(Prior Art)

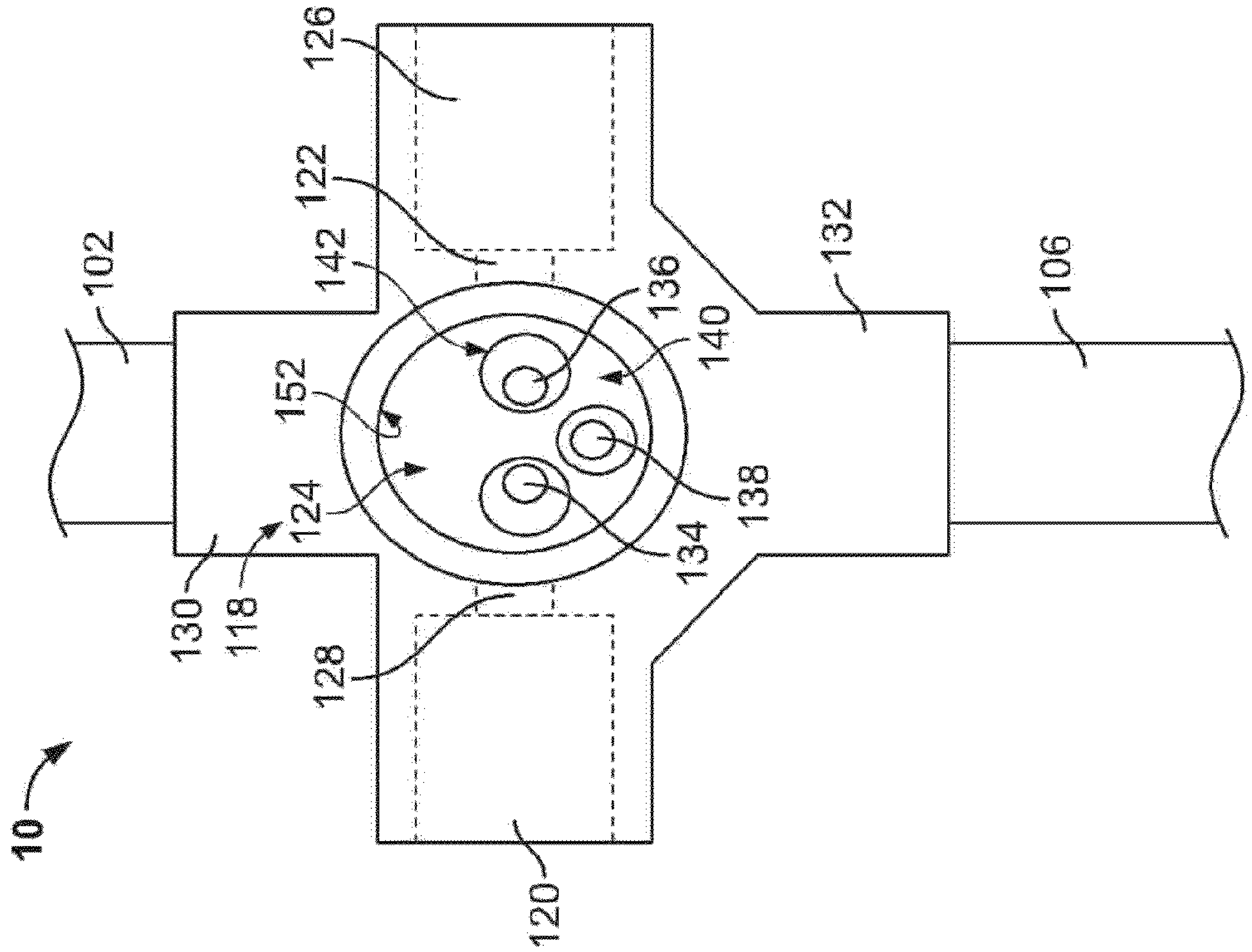


FIG. 6
(Prior Art)

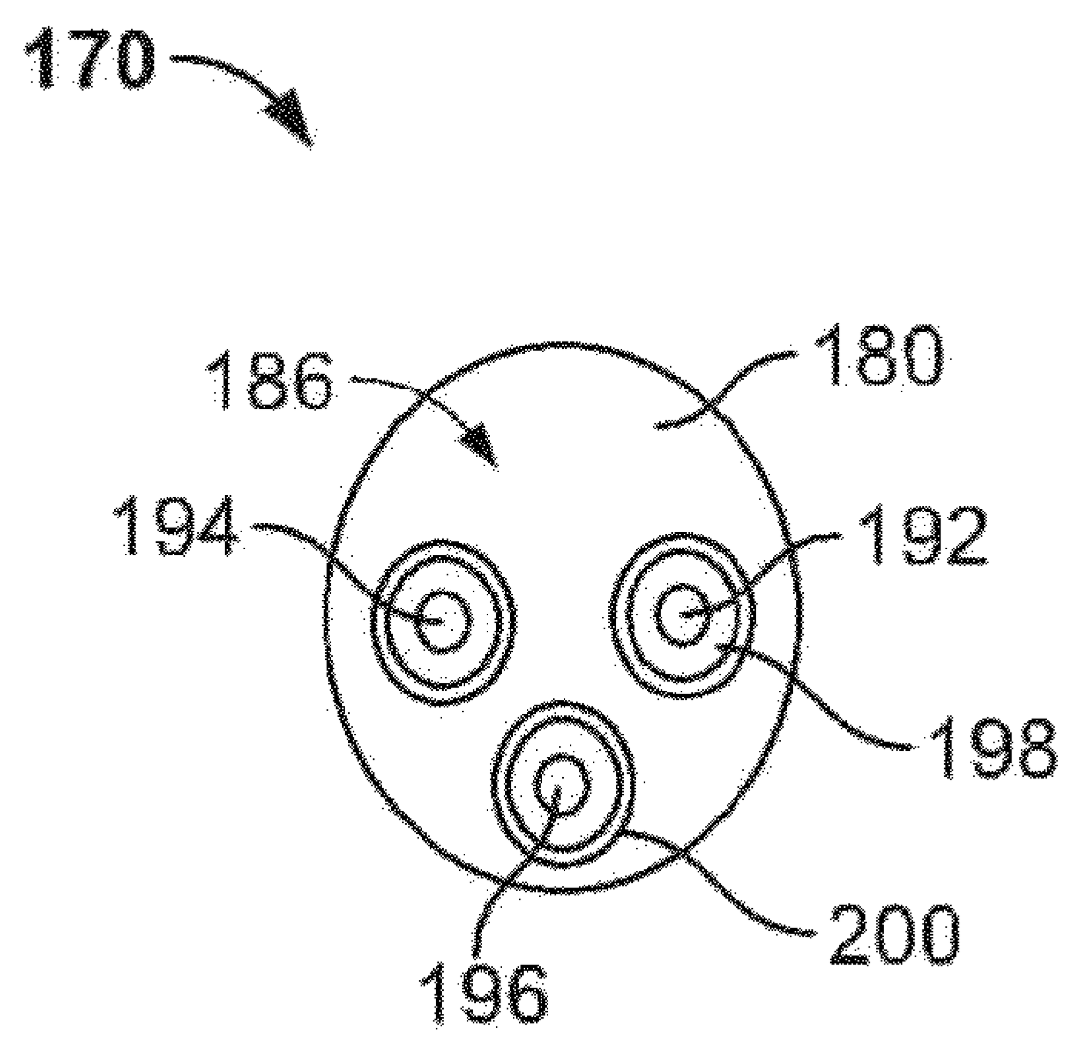


FIG. 7

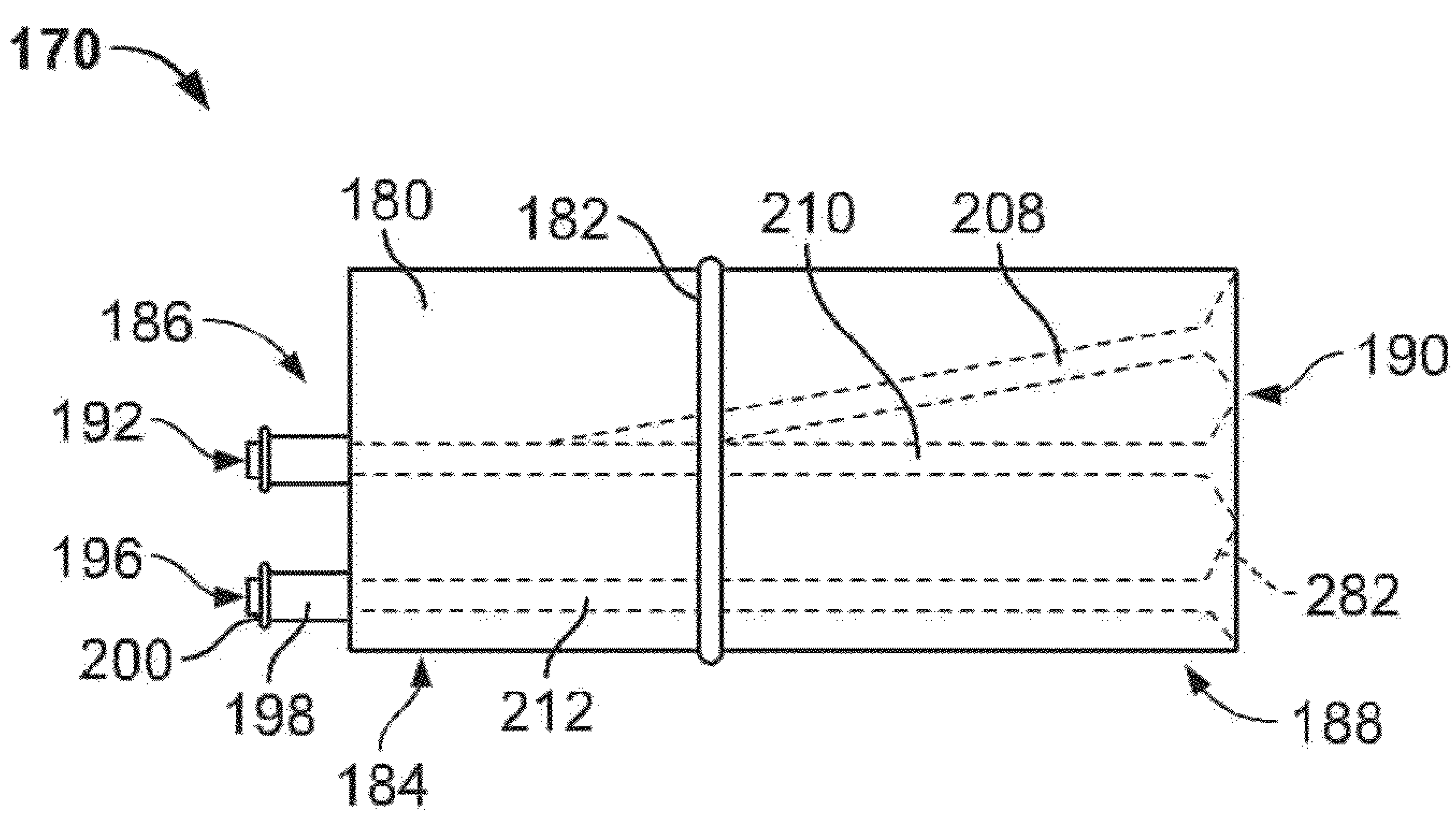


FIG. 8

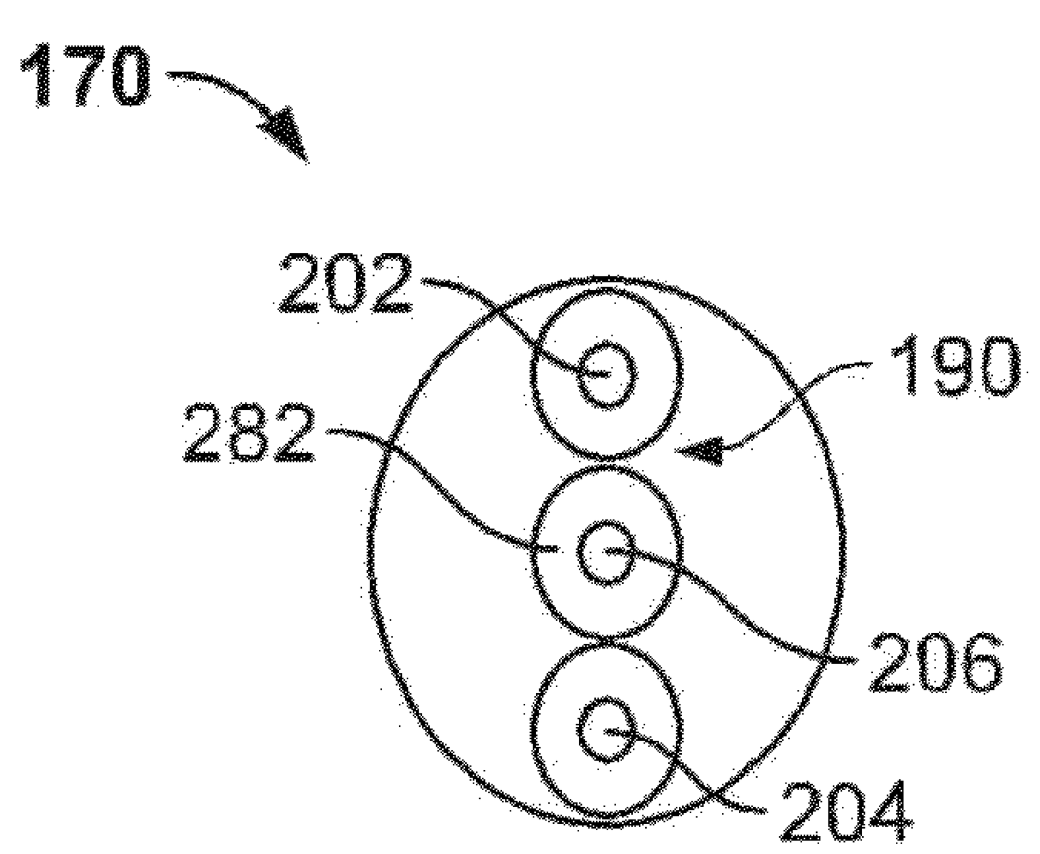
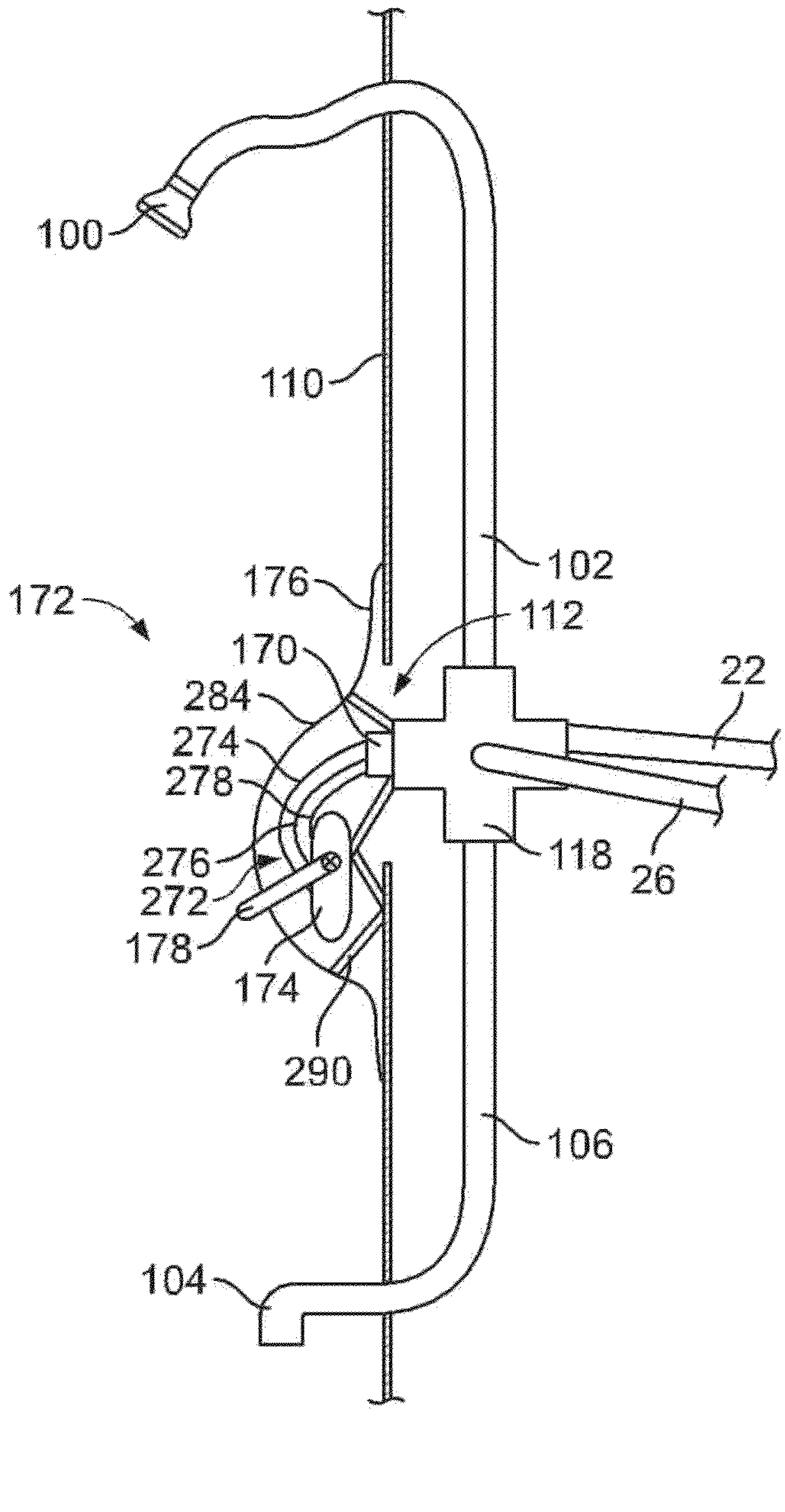


FIG. 9


100
110
102
176
172
112
170
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284
274
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118
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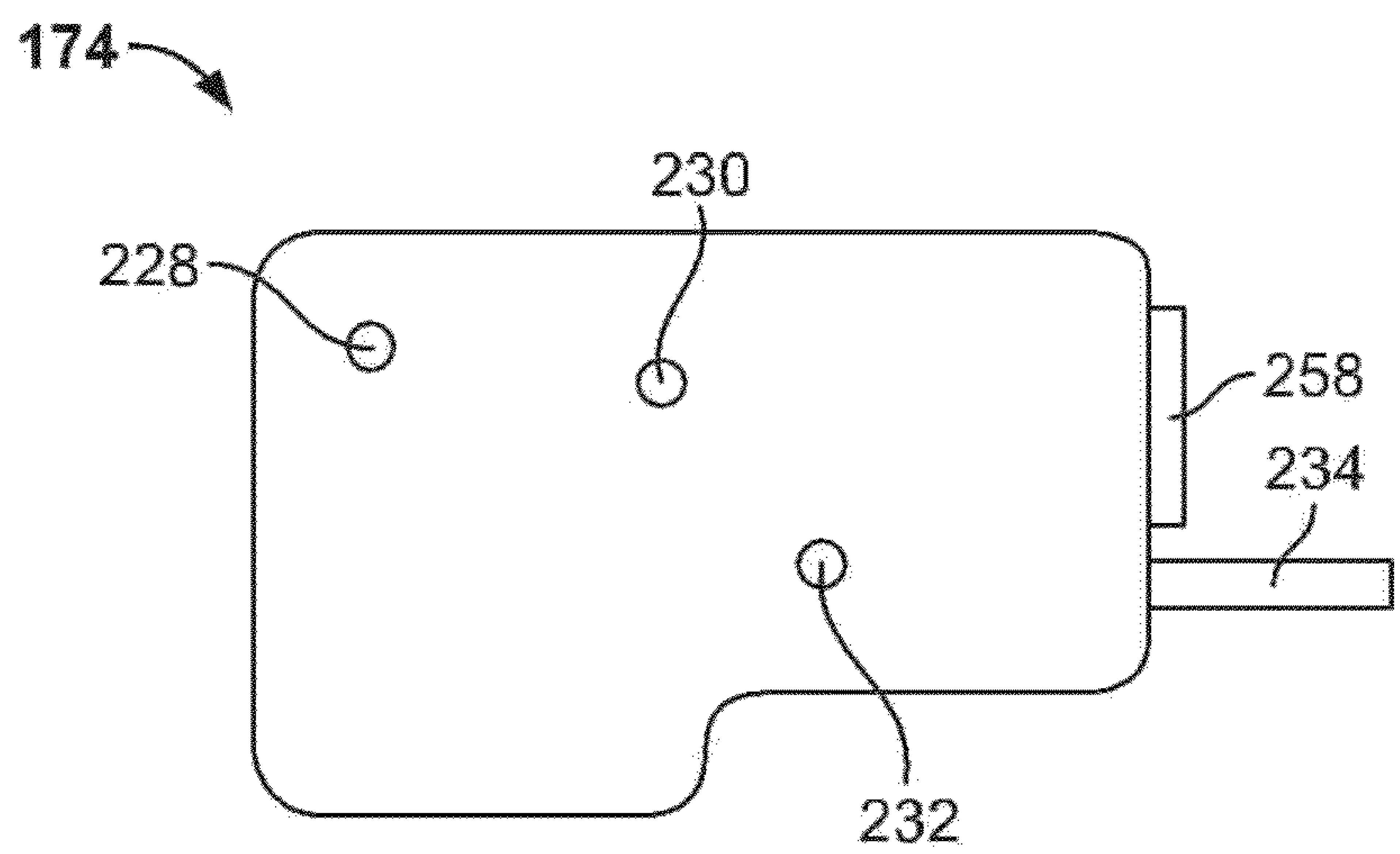
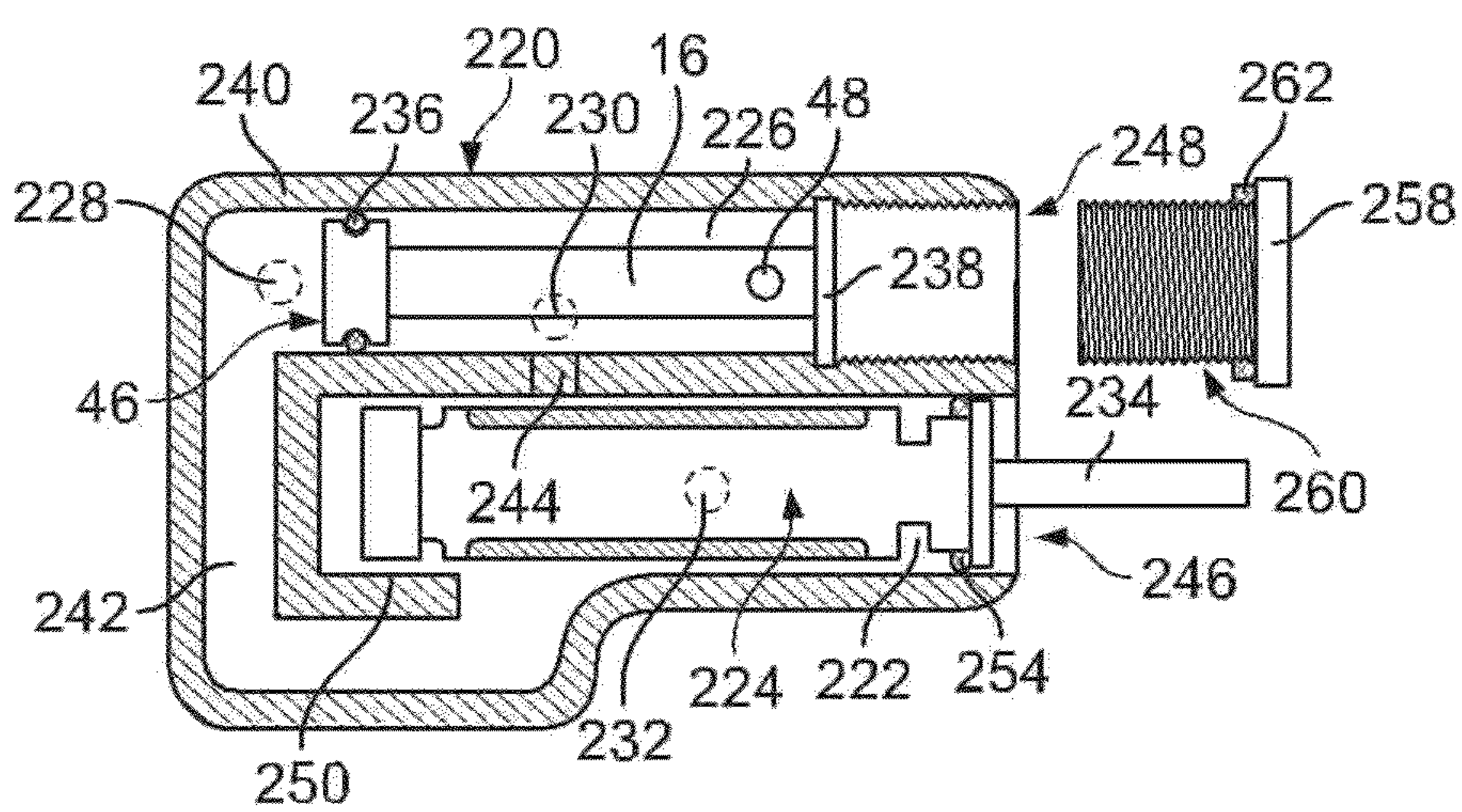
104

FIG. 10



174
230
228
258
234
232

FIG. 11



220
16
240
236
230
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48
262
228
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238
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234
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222
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232
250

FIG. 12

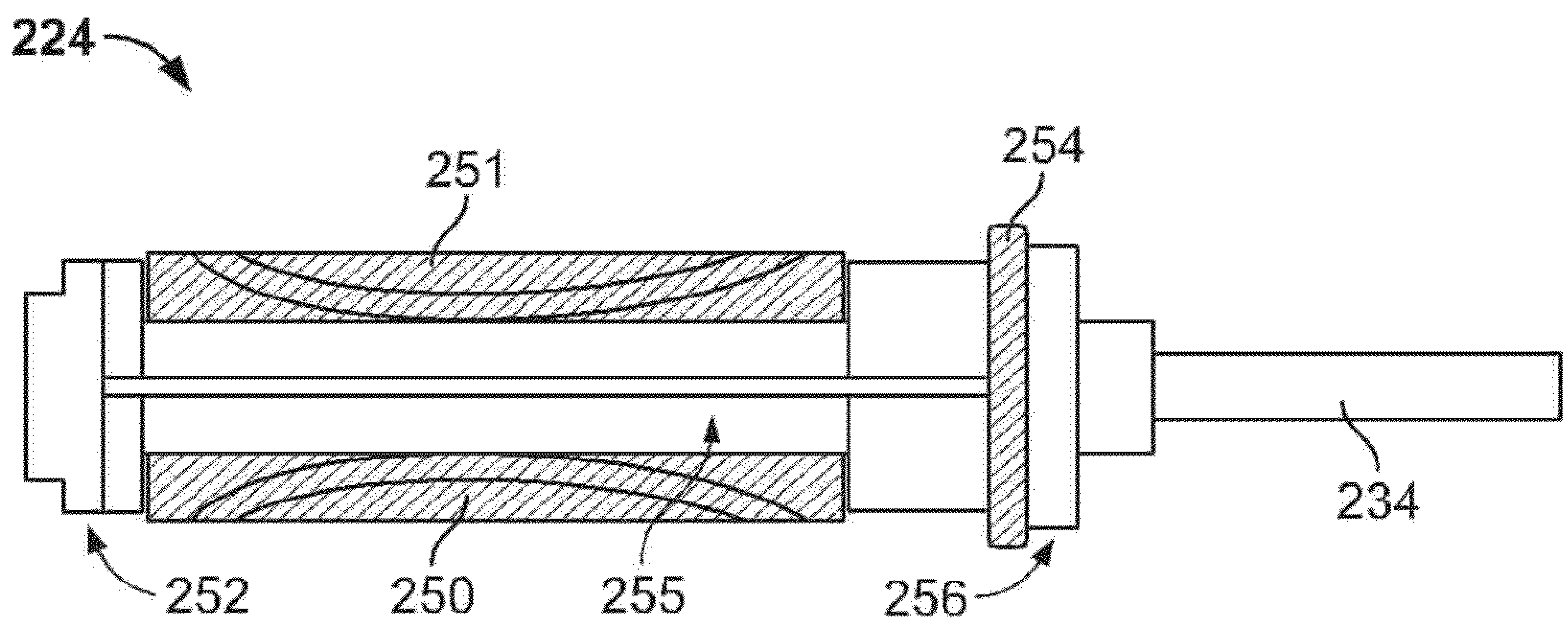

FIG. 13
(Prior Art)

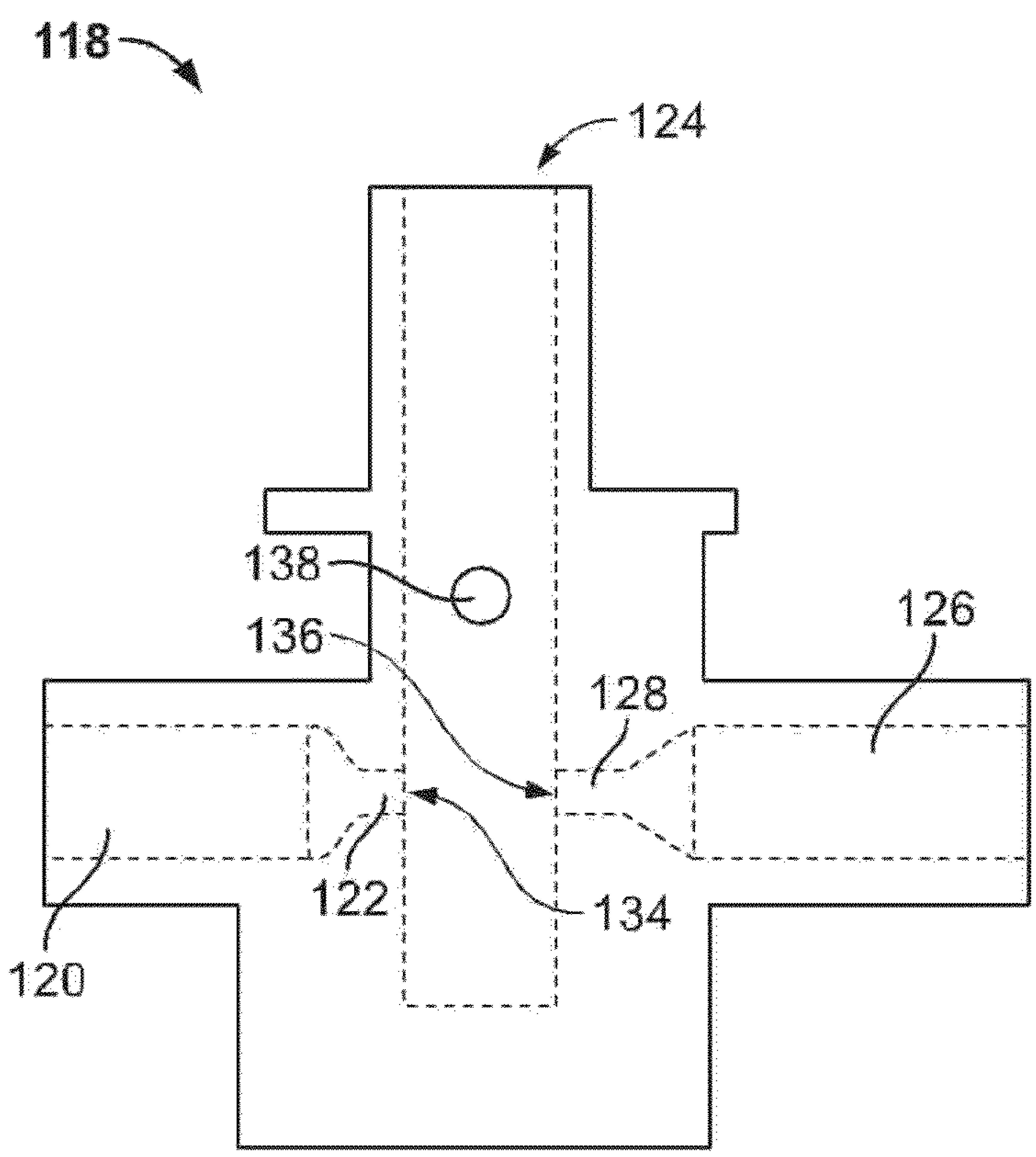

FIG. 14
(Prior Art)

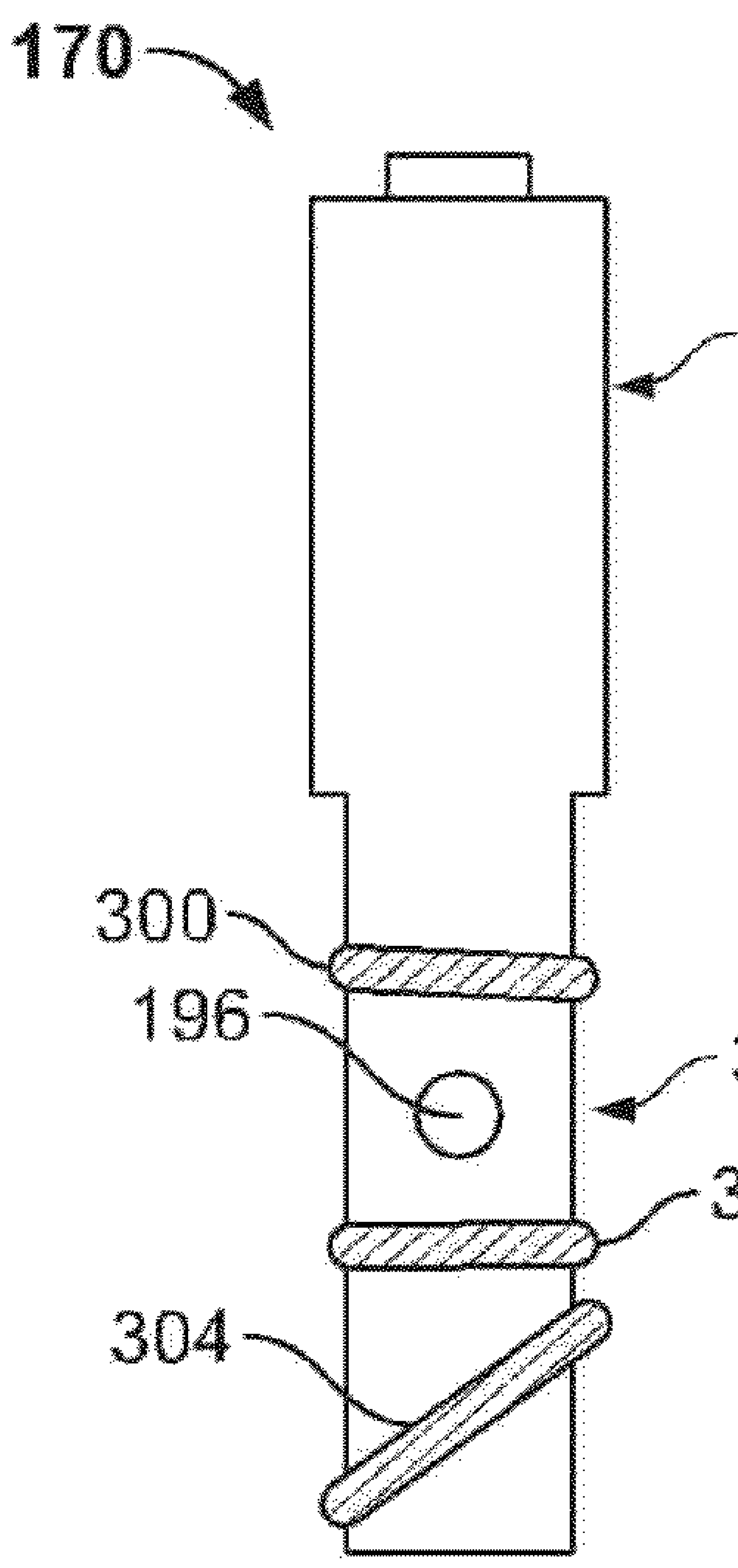

FIG. 15

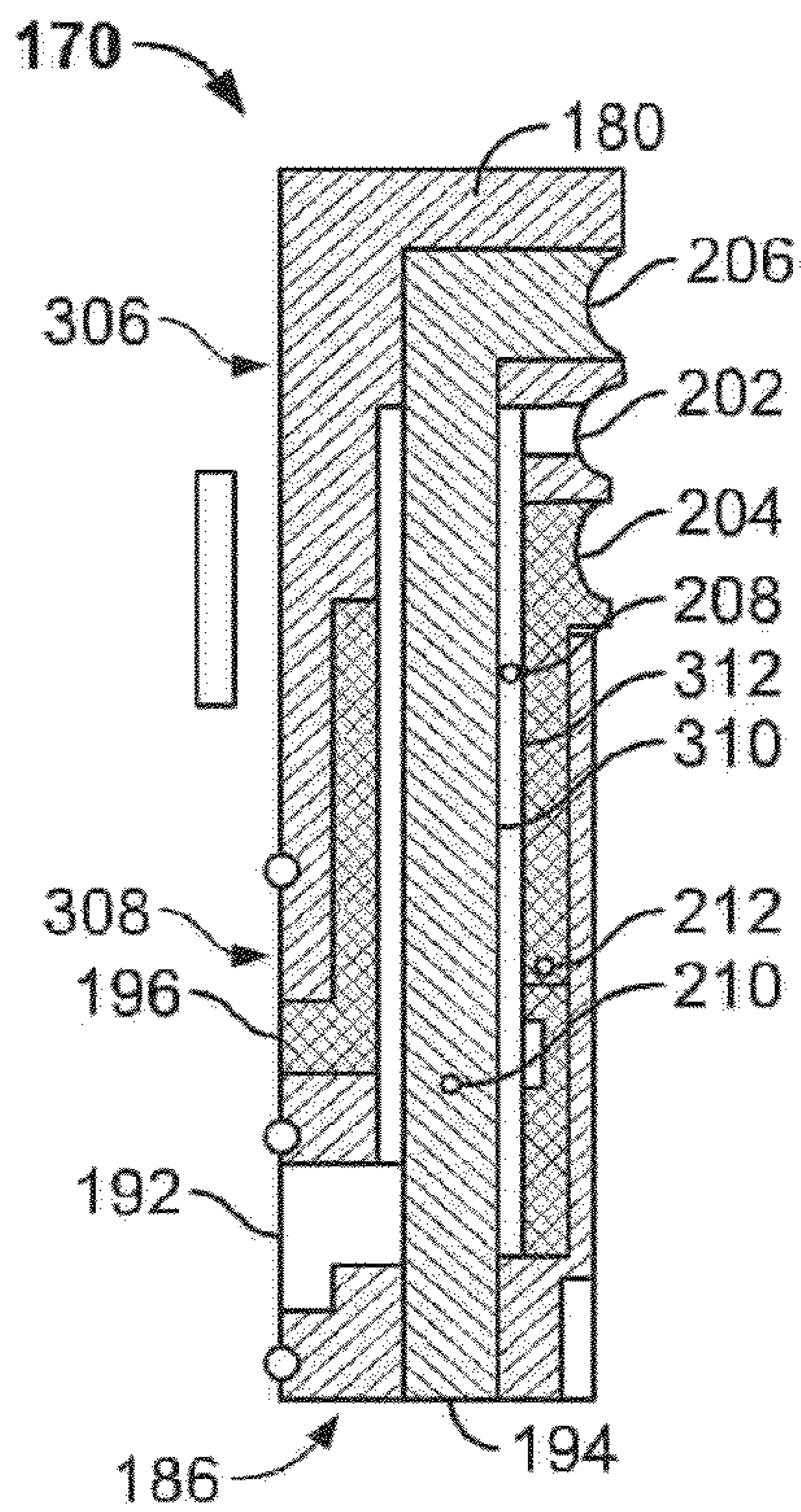

FIG. 16

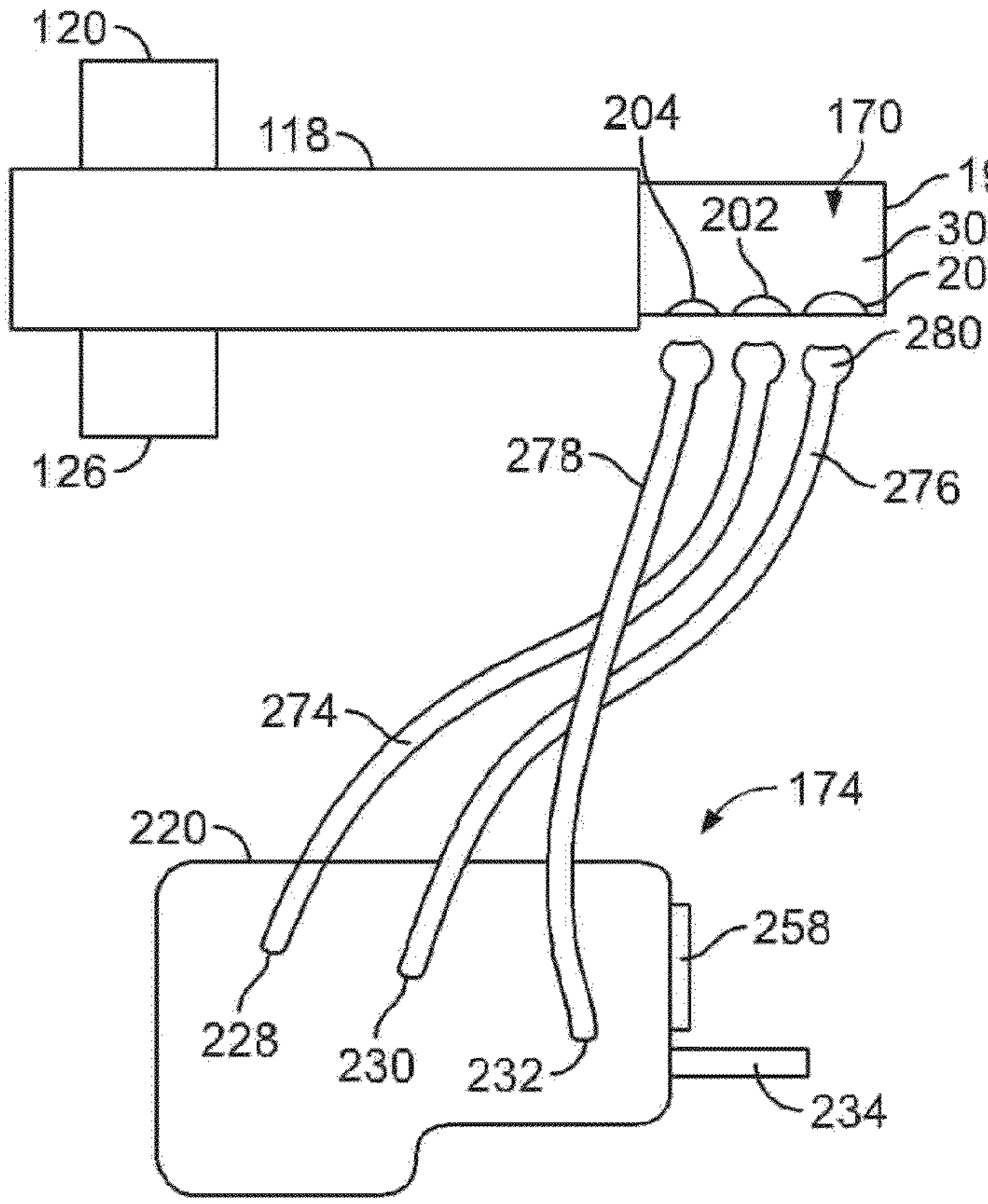

FIG. 17

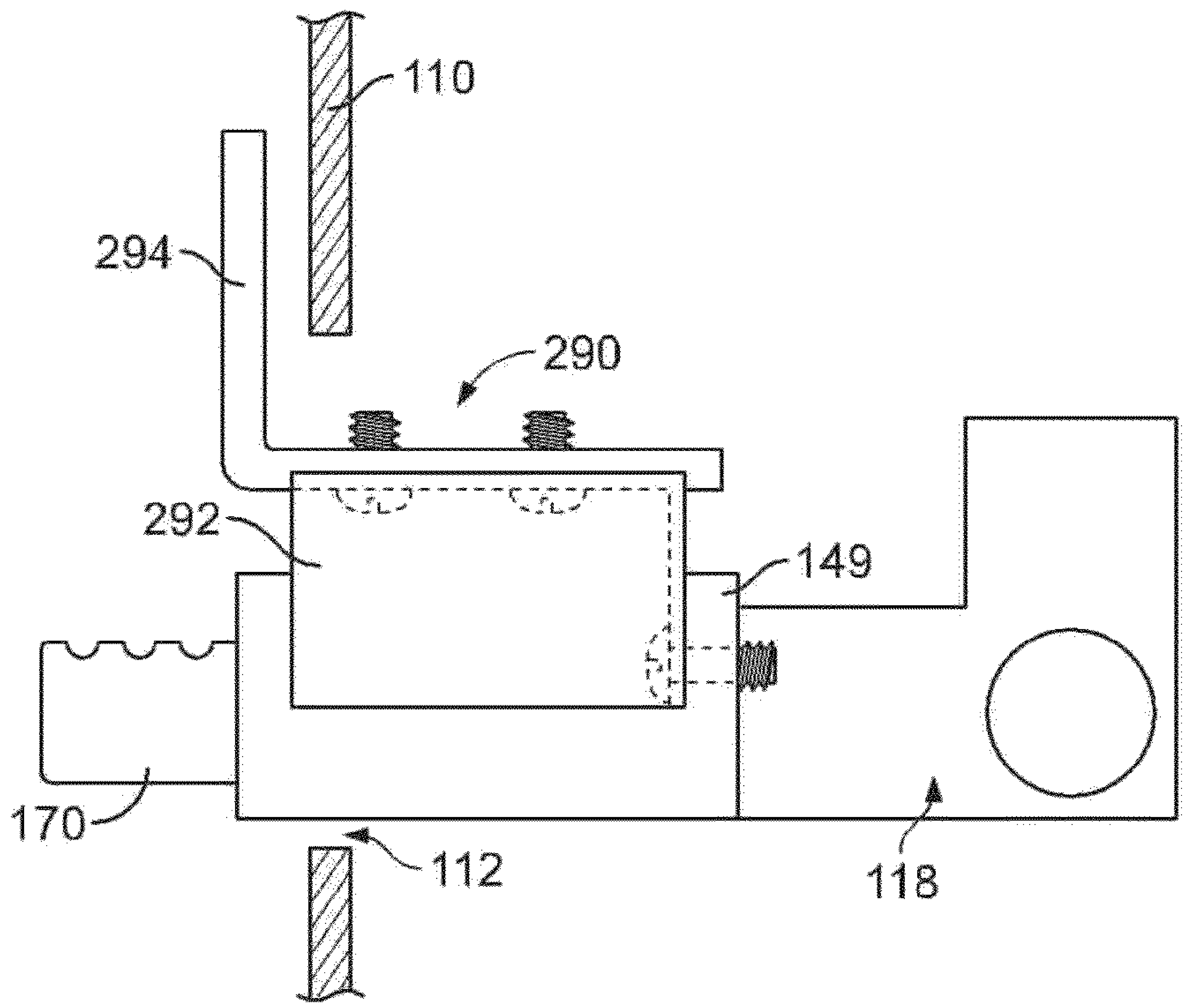
110
294
290
292
149
170
112
118

FIG. 18

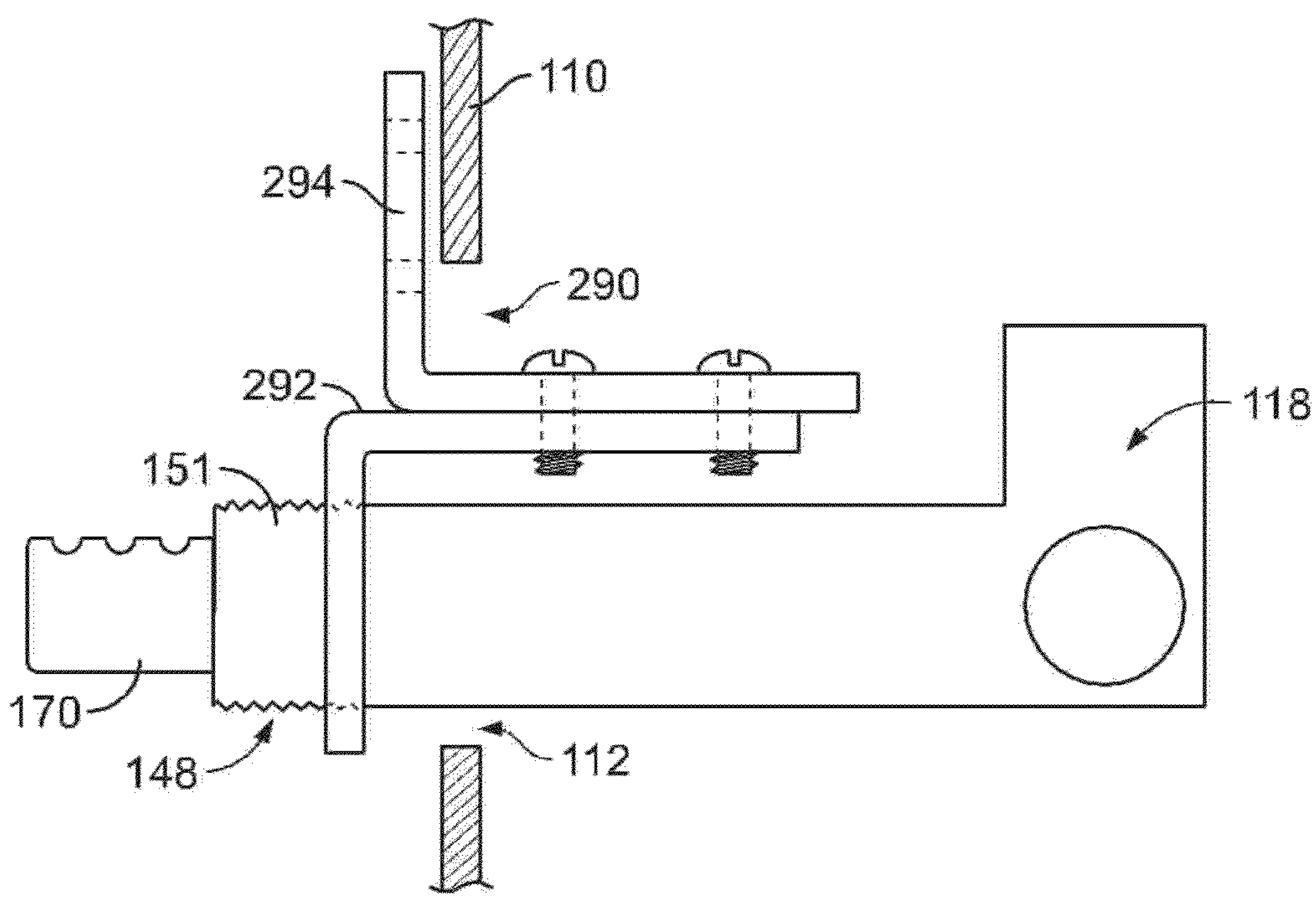
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FIG. 19

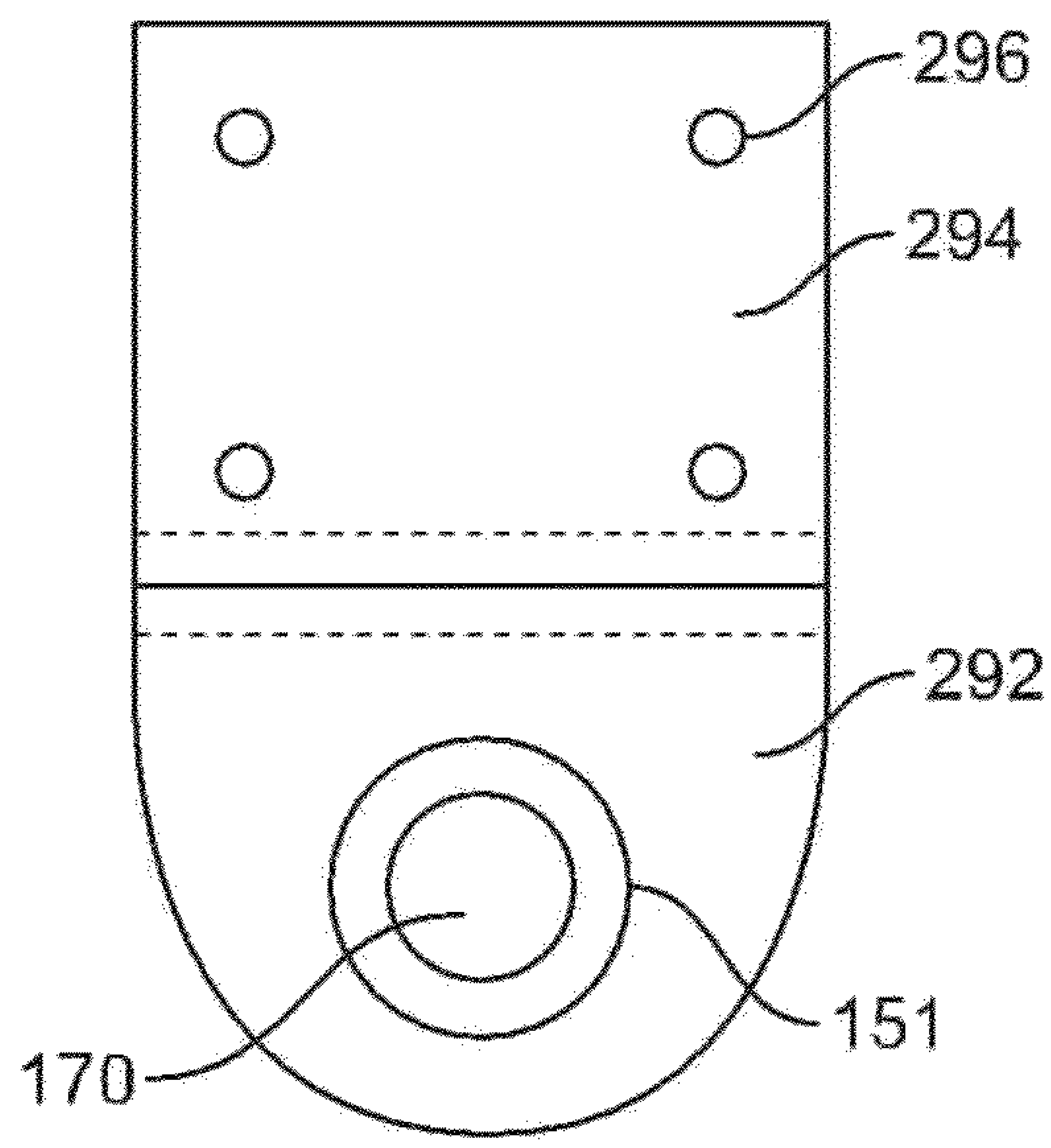


FIG. 20

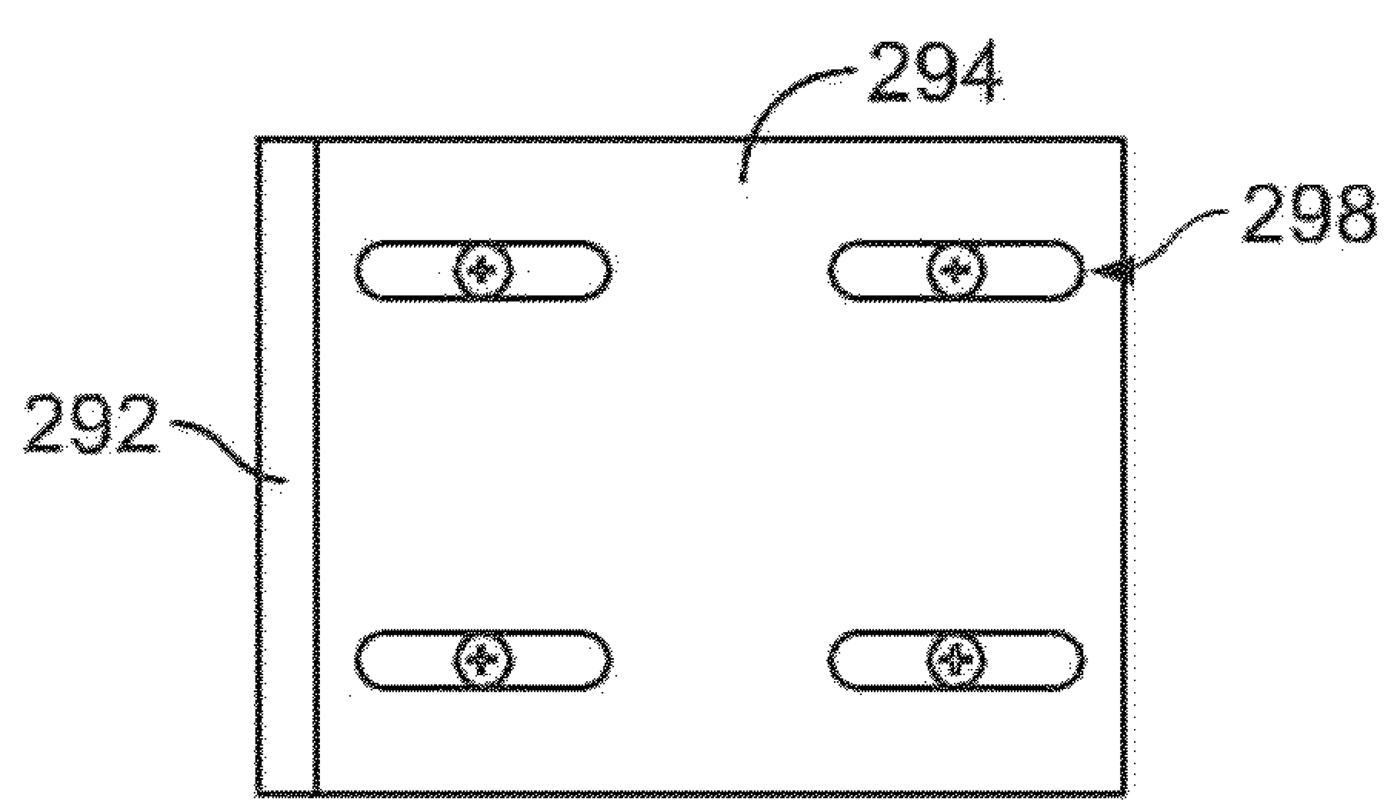


FIG. 21

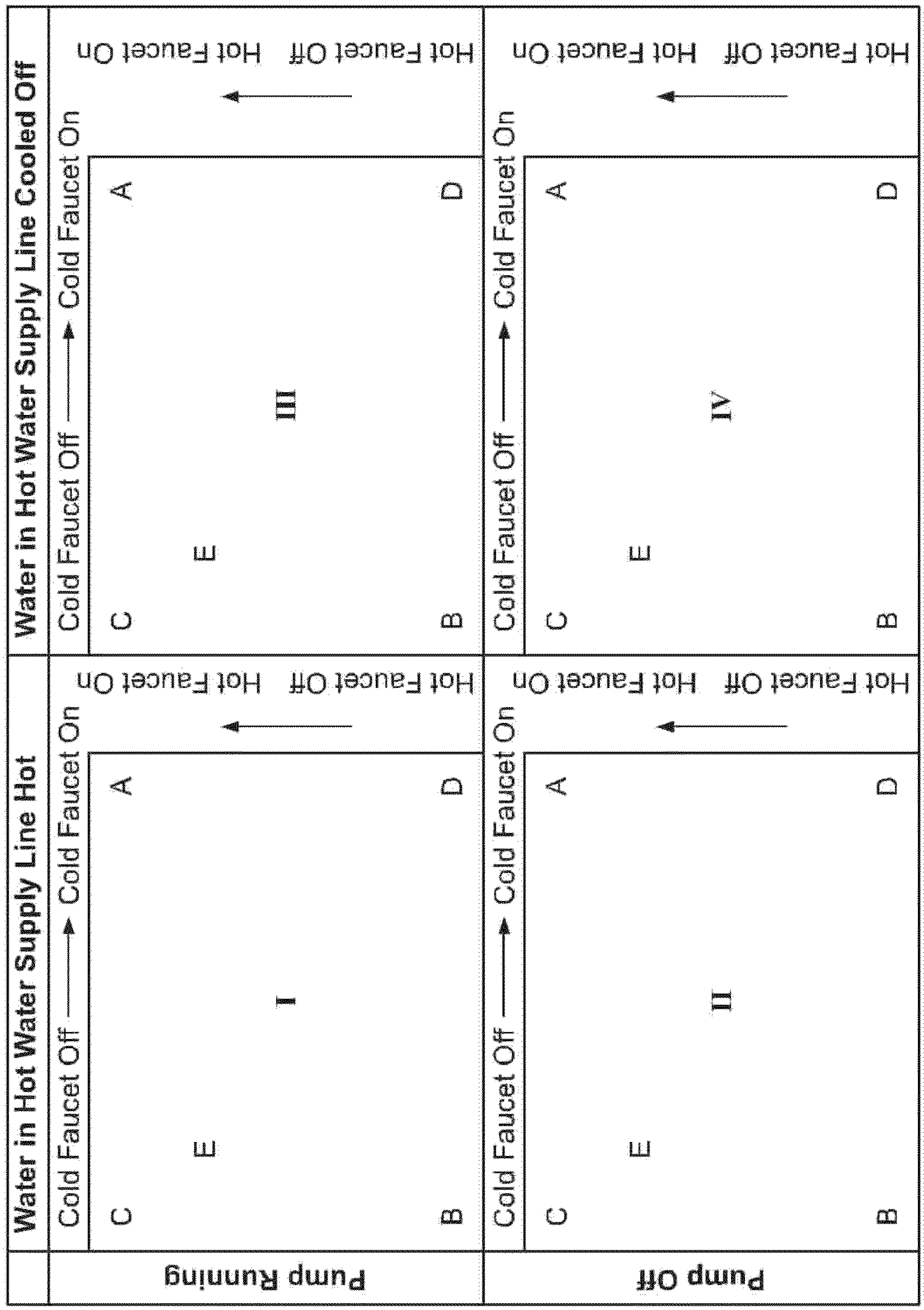

Water in Hot Water Supply Line Hot
Water in Hot Water Supply Line Cooled Off
Pump Running
Pump Off
Cold Faucet Off
Cold Faucet On
Hot Faucet On
Hot Faucet Off
A
B
C
D
E
I
II
III
IV

FIG. 22

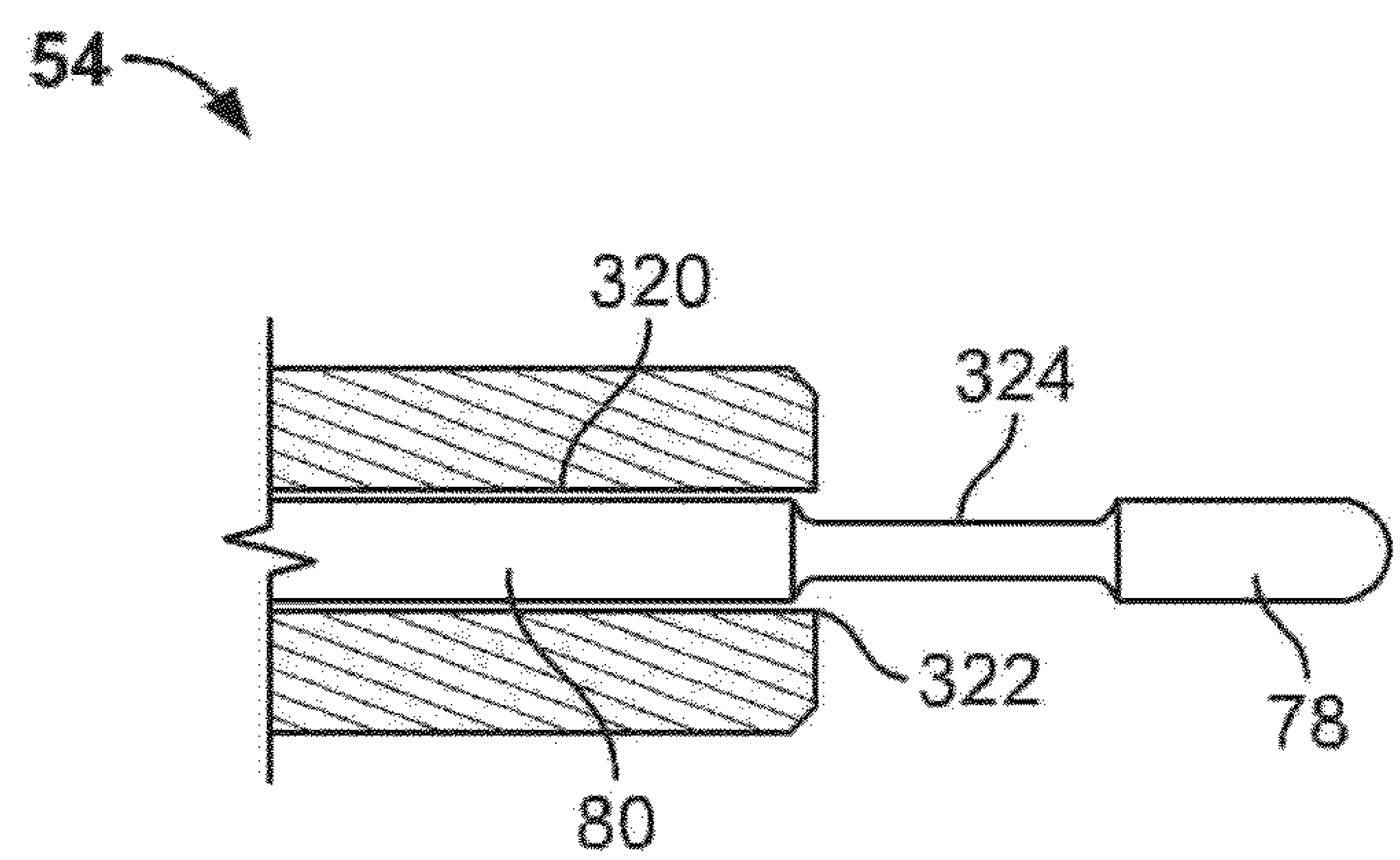

54
320
324
322
78
80

FIG. 23

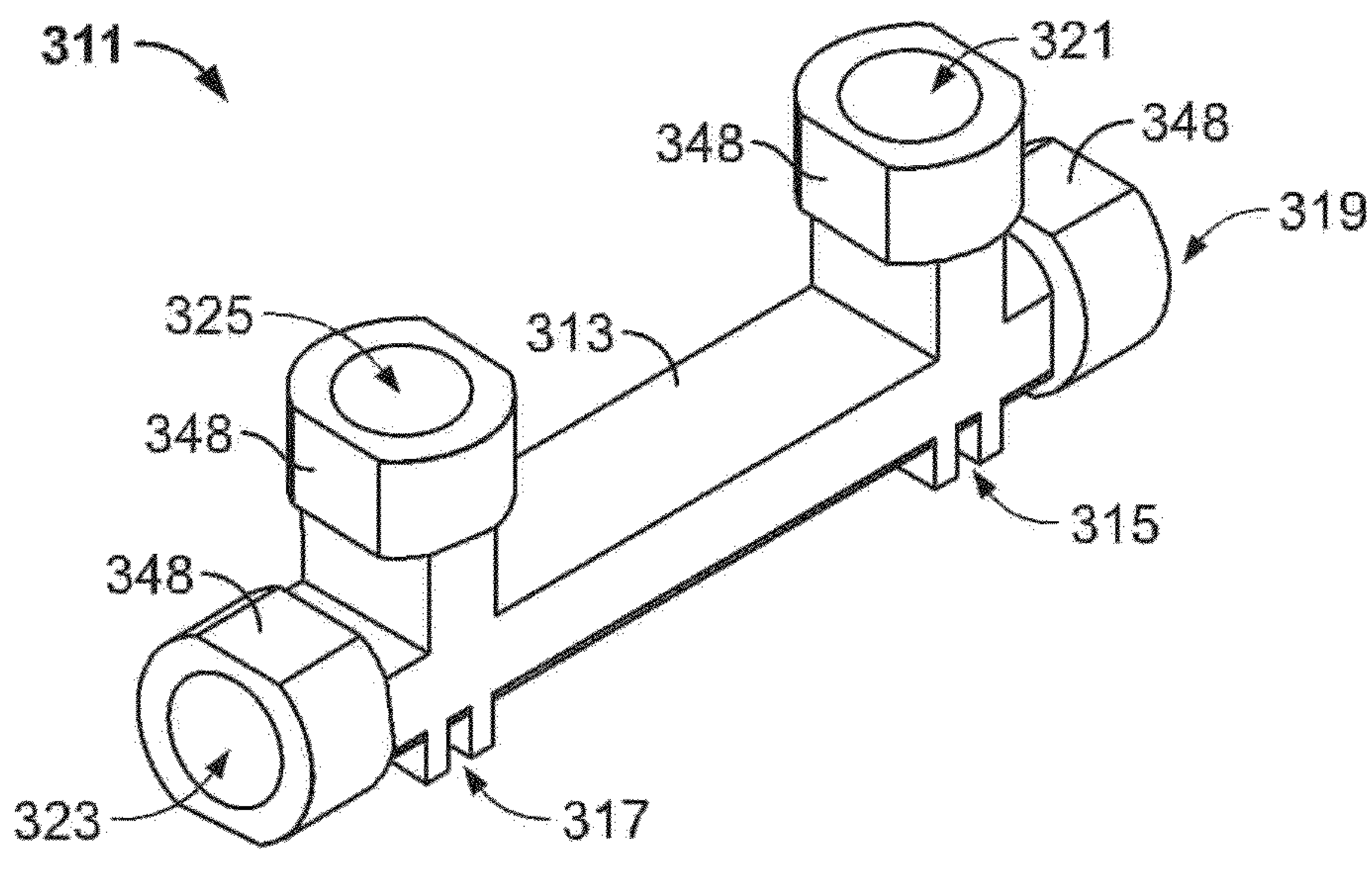

311
321
348
348
319
325
313
348
315
348
323
317

FIG. 24

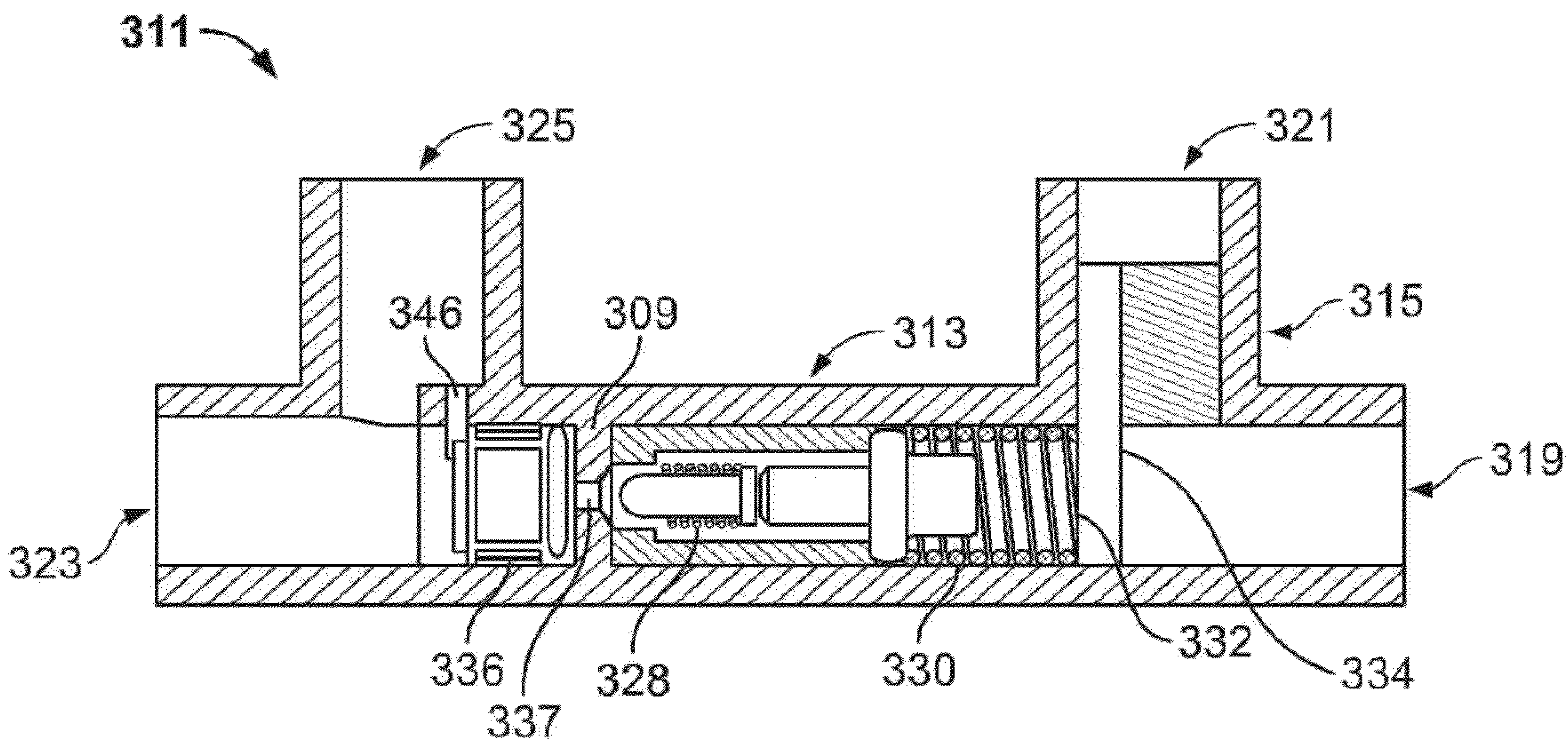
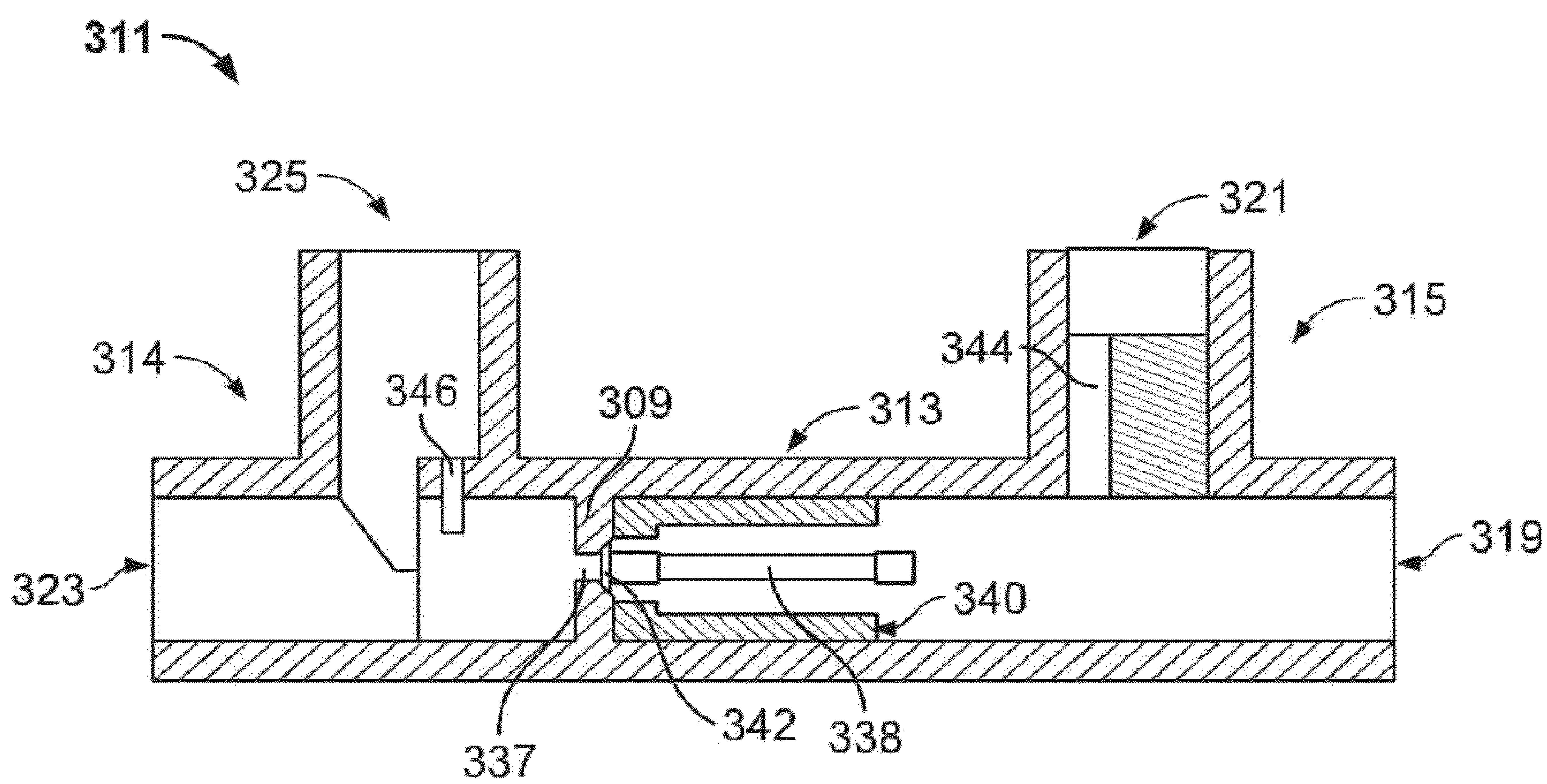

311
325
321
346
309
313
315
319
323
336
337
328
330
332
334

FIG. 25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325
321
315
314
344
346
309
313
319
323
340
337
342
338

FIG. 26

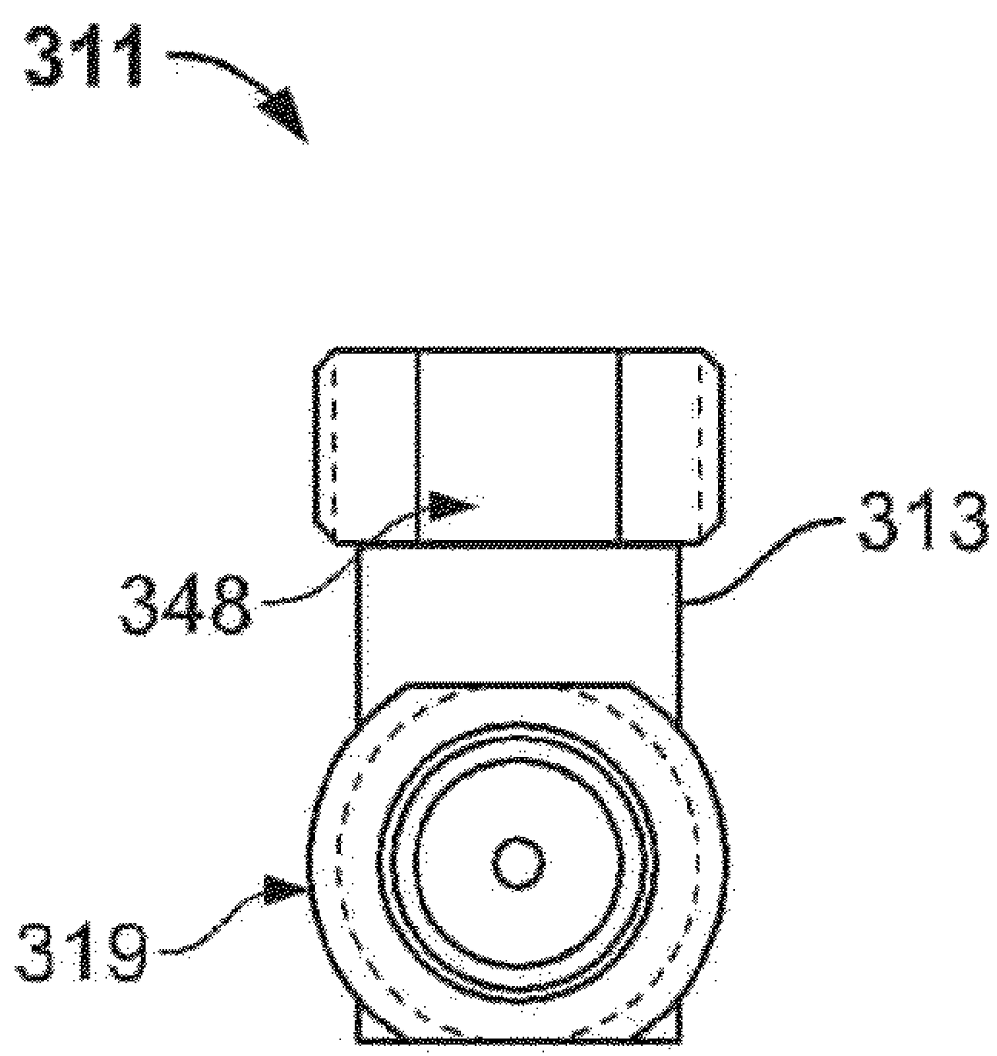


FIG. 27

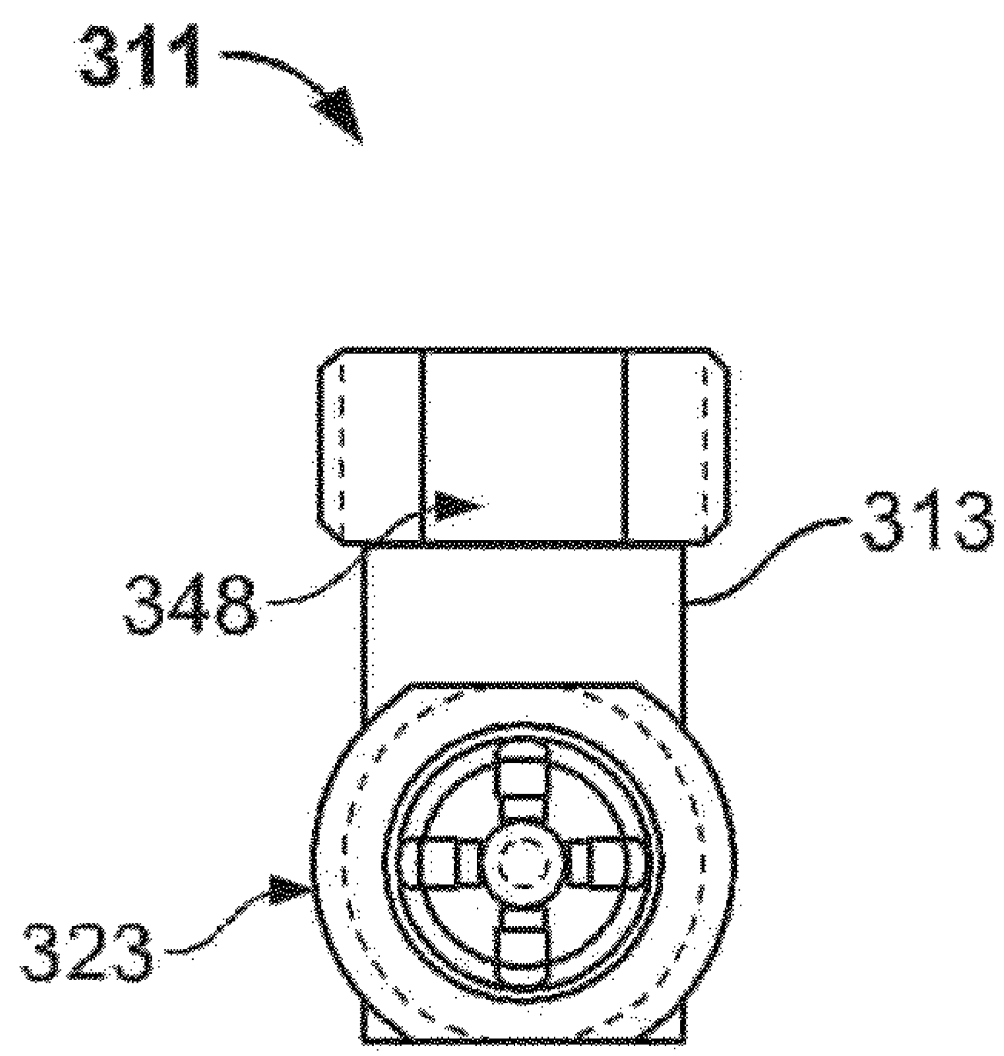


FIG. 28

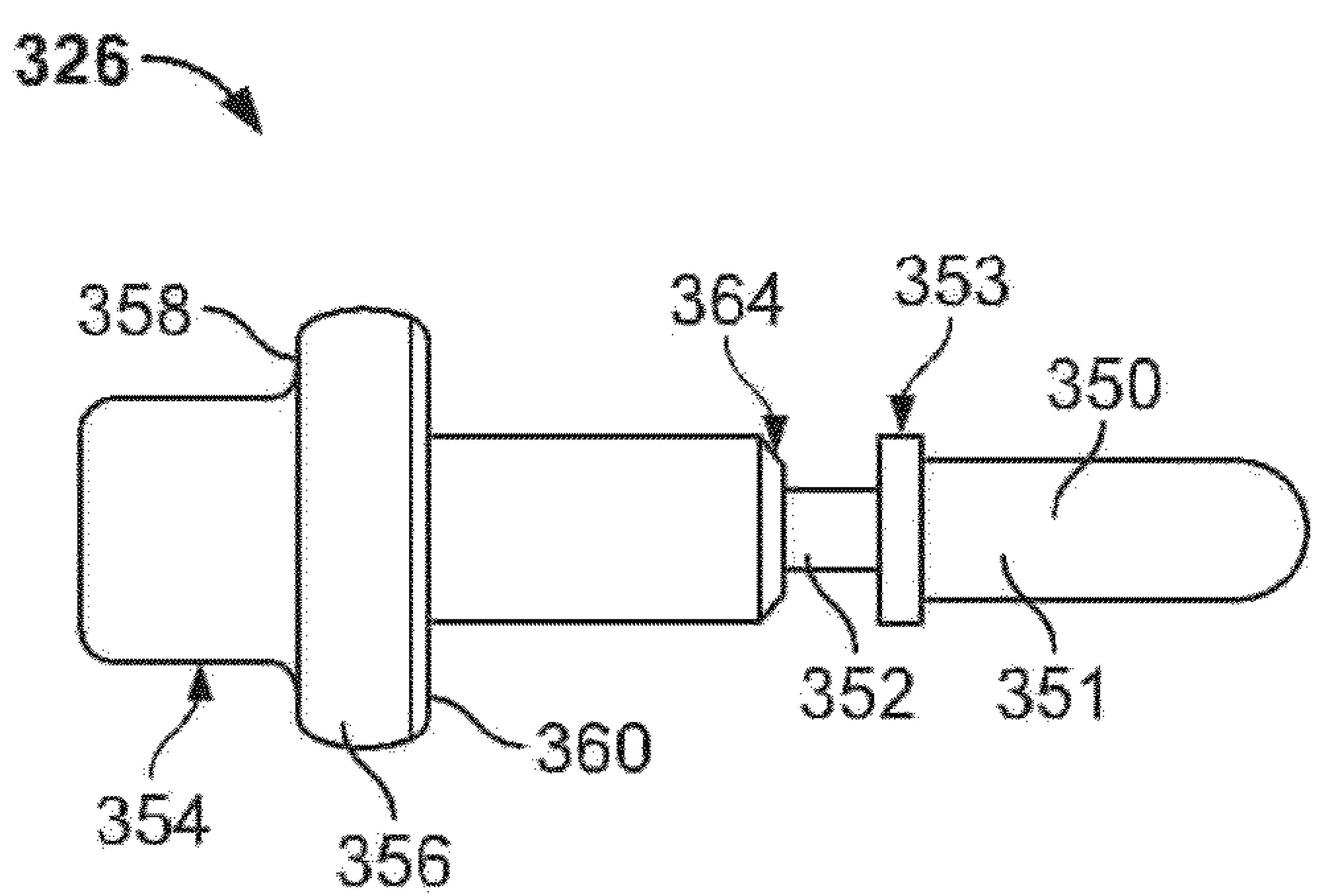


FIG. 29

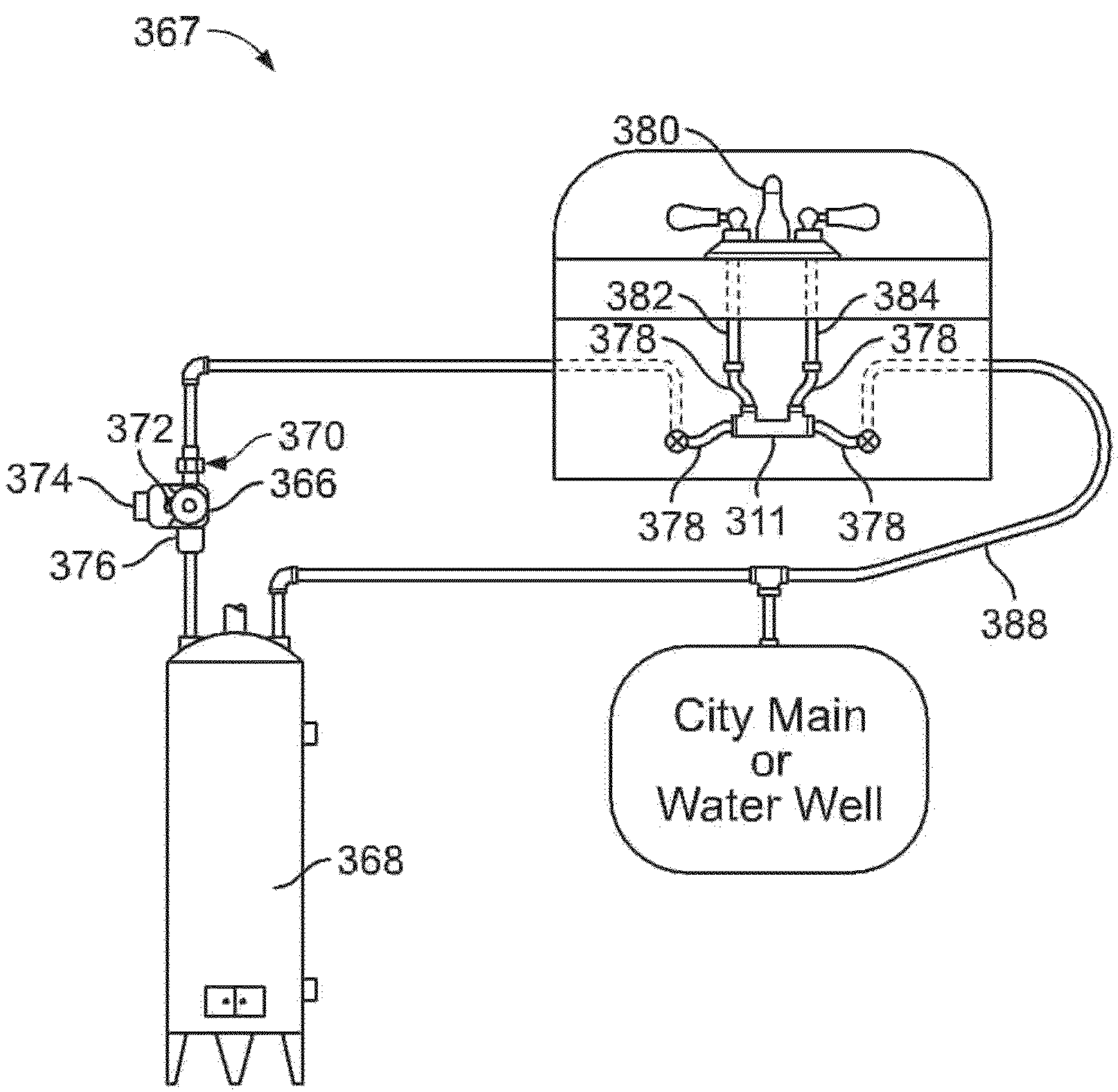
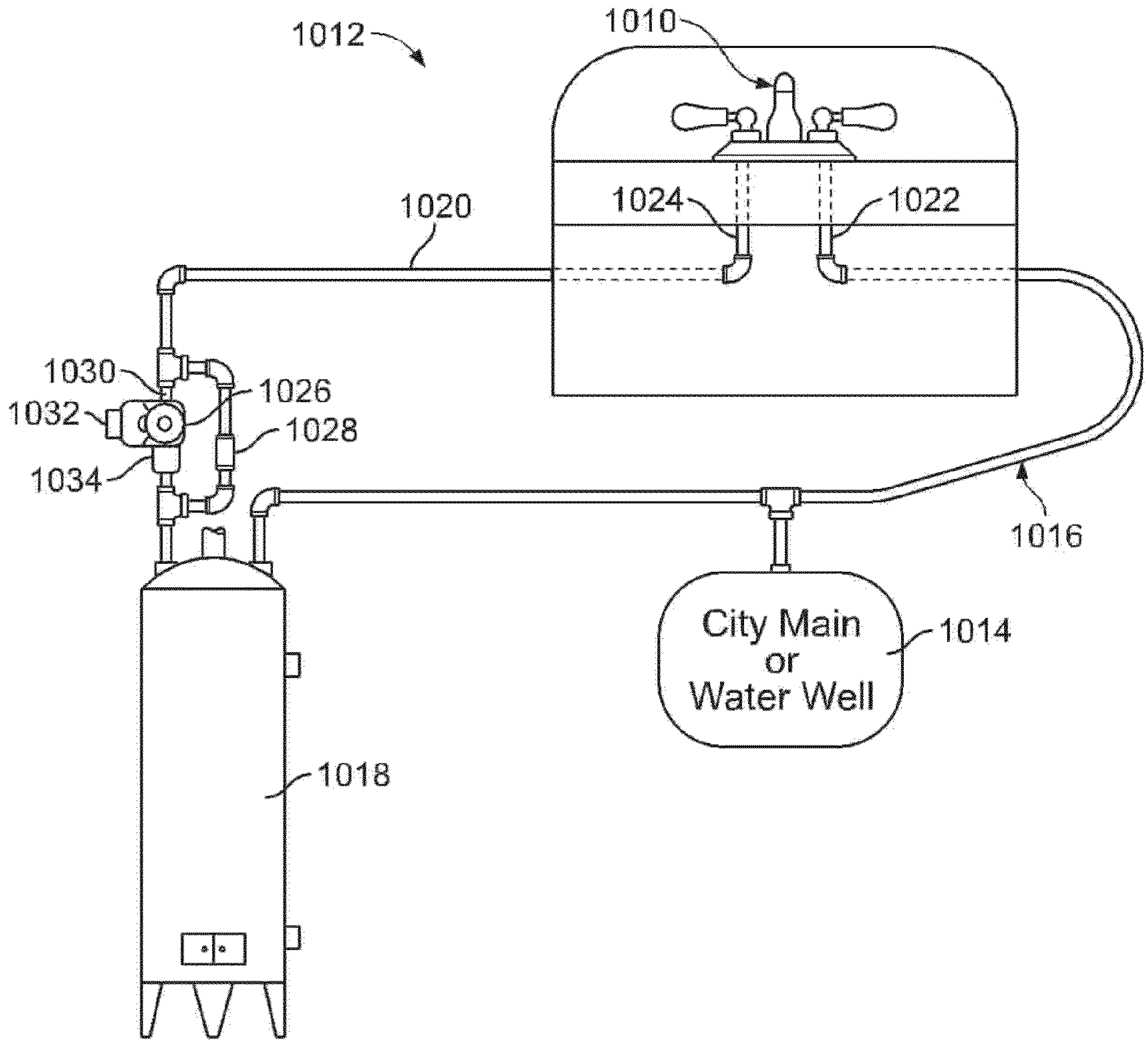

367
380
382
384
378
378
372
370
374
366
376
378
311
378
388
City Main
or
Water Well
368

FIG. 30


1012
1010
1020
1024
1022
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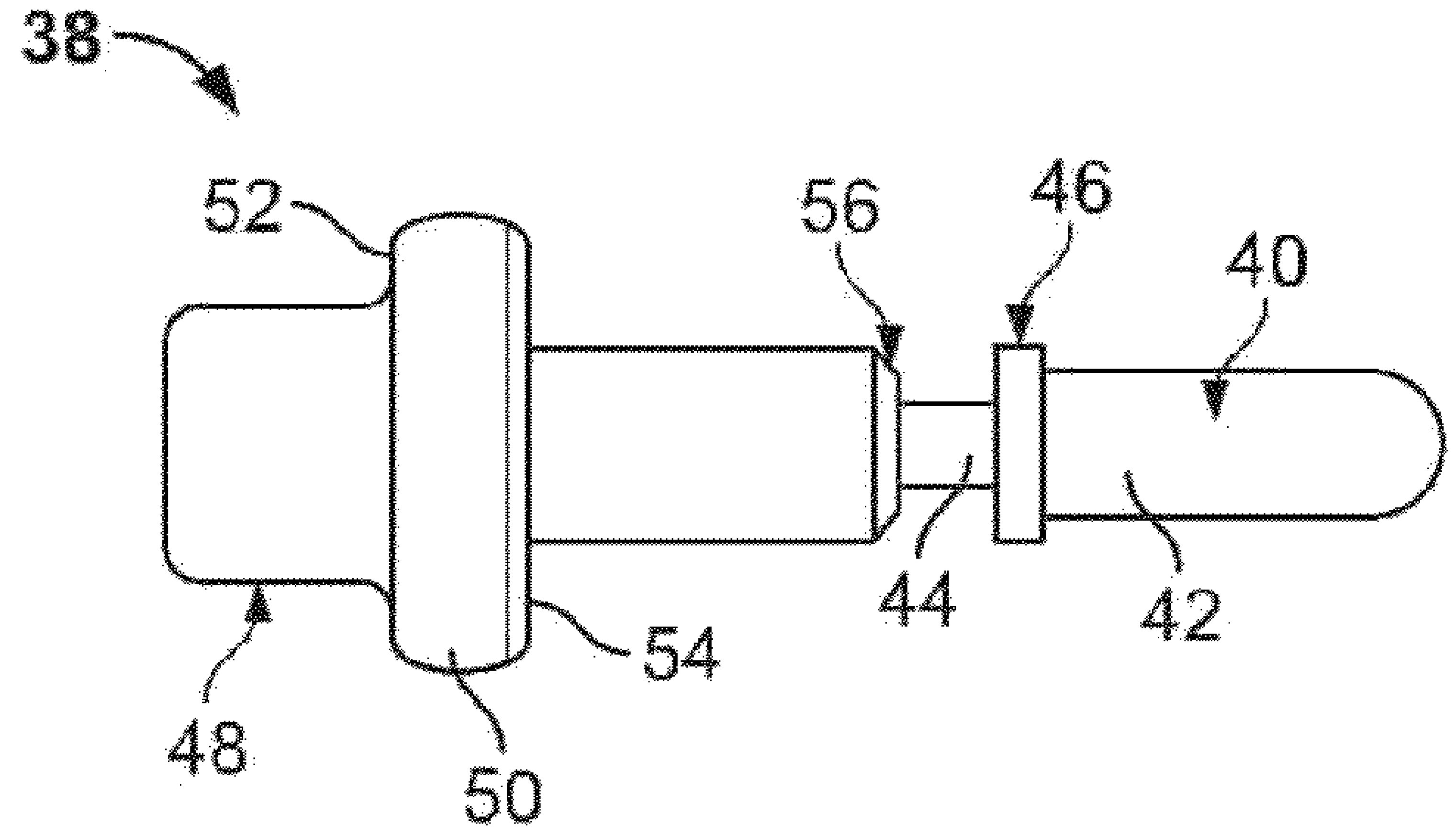
1032
1028
1034
1016
City Main
or
Water Well
1014
1018

FIG. 31


38
52
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48
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FIG. 32

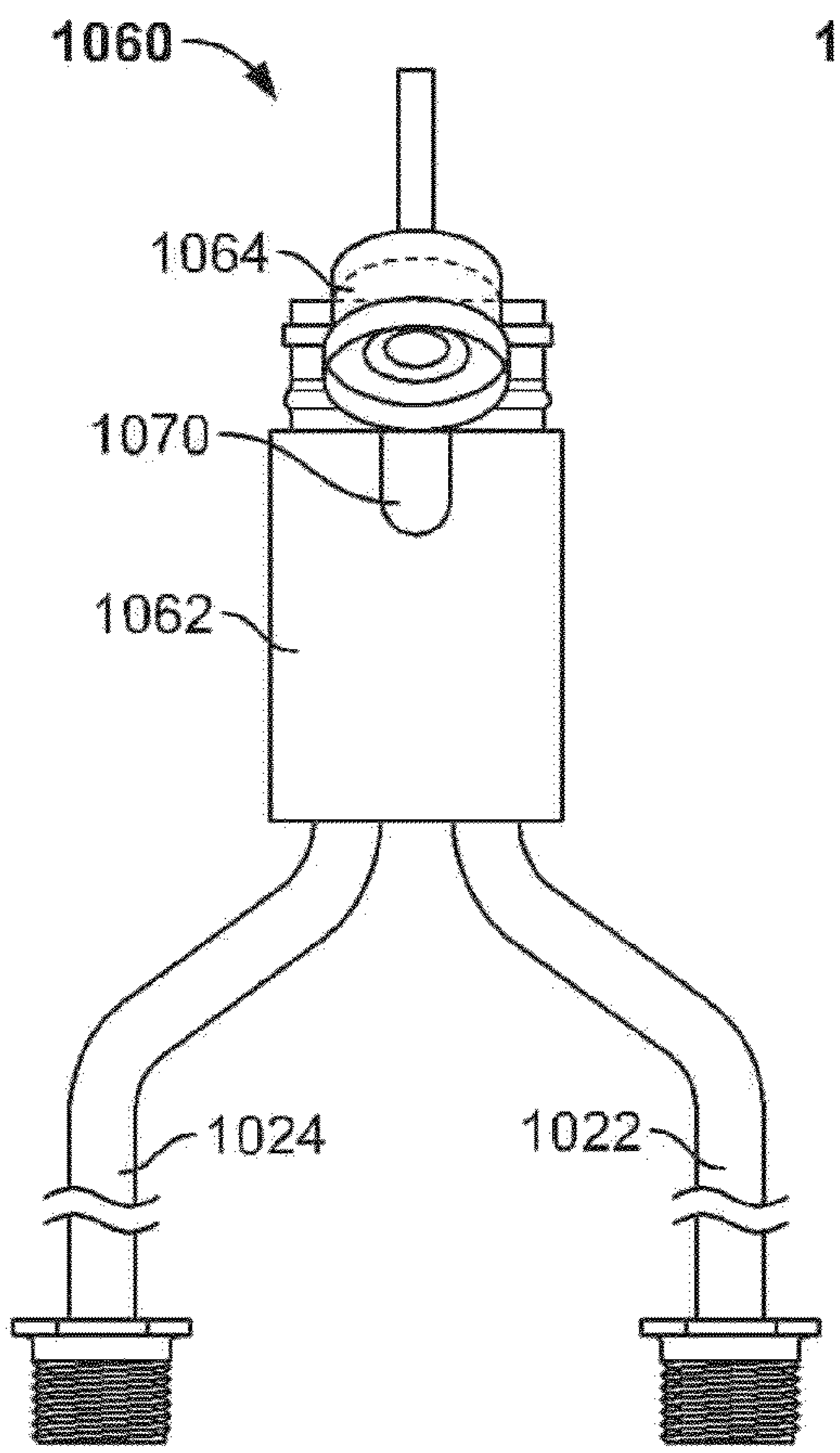


FIG. 33

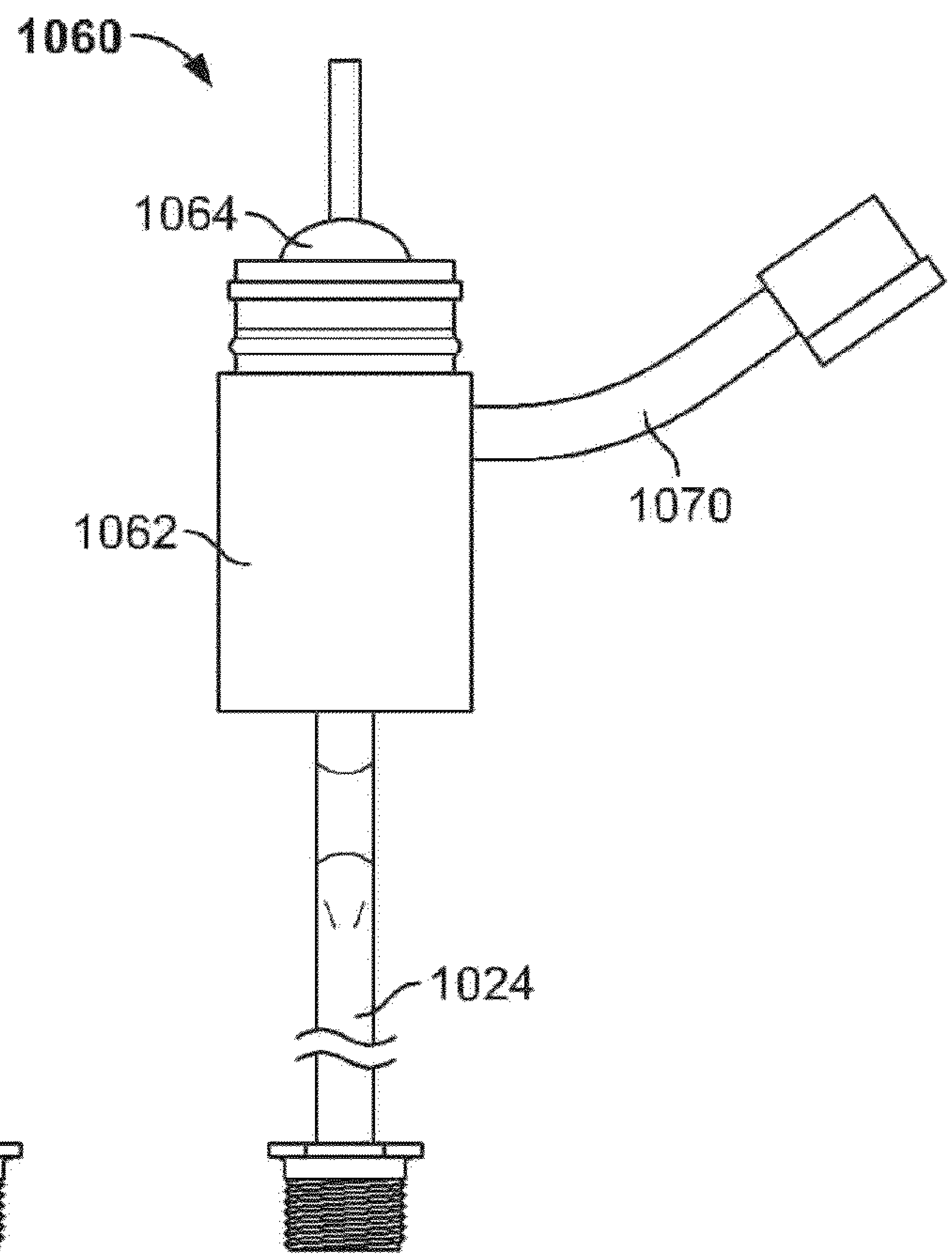


FIG. 34

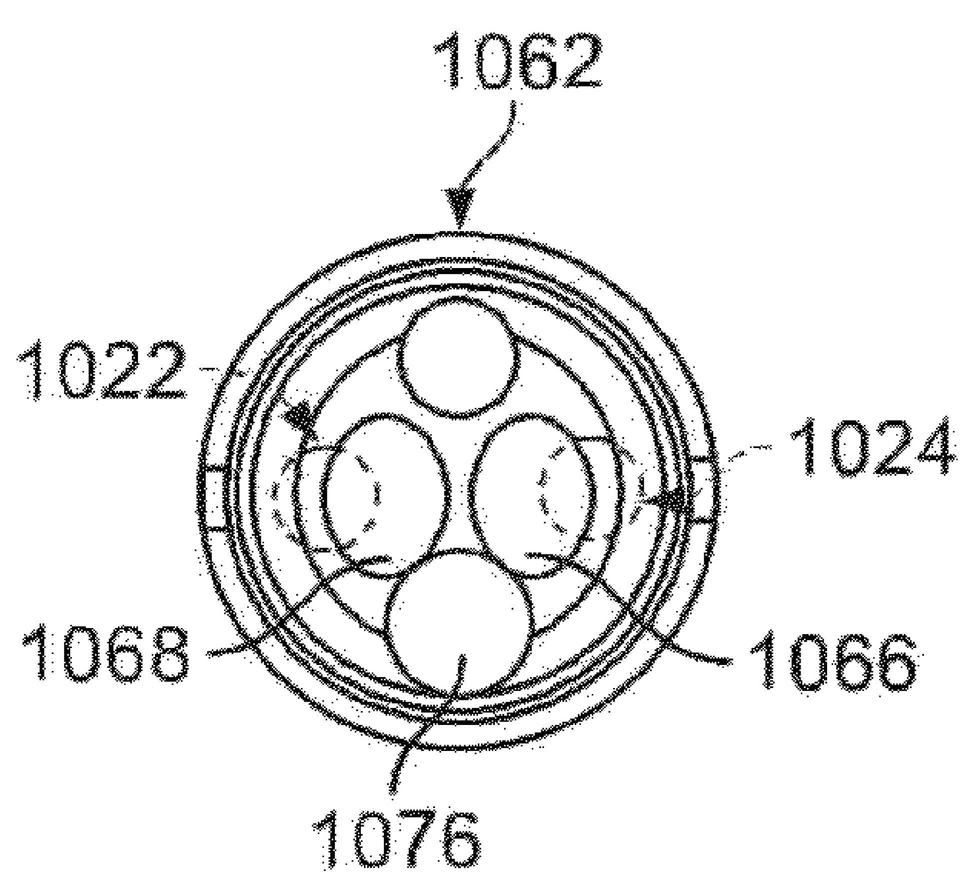


FIG. 35

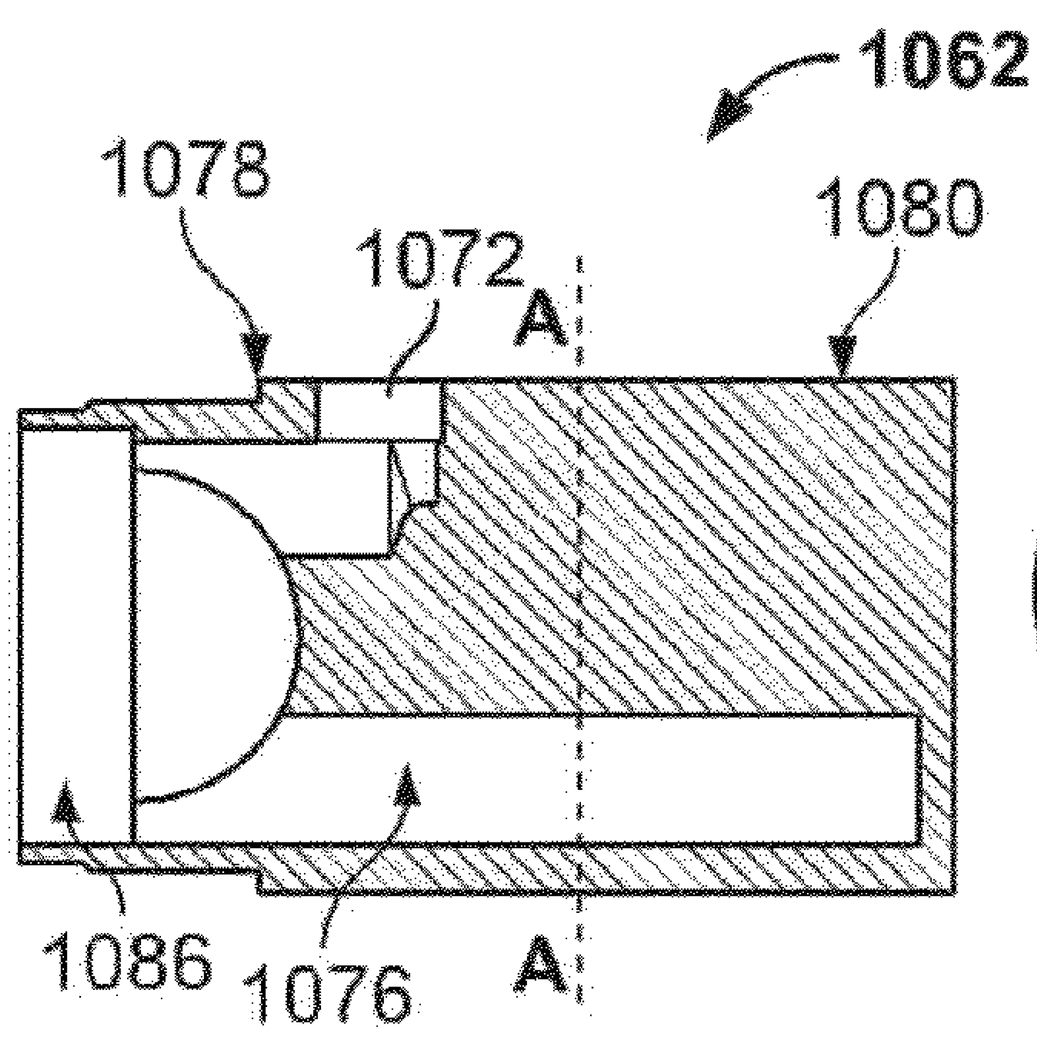


FIG. 36

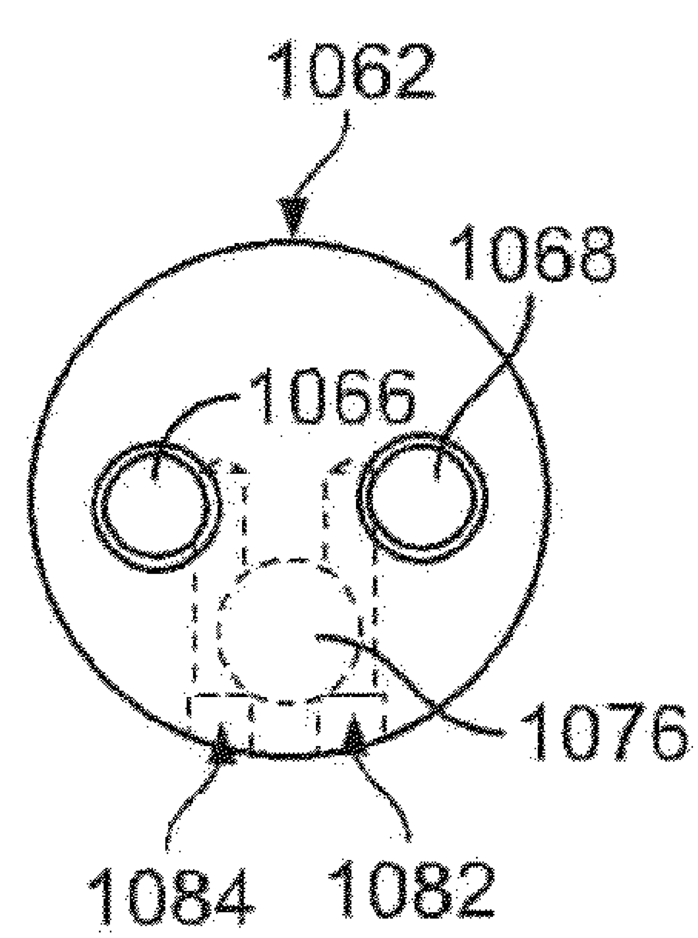


FIG. 37

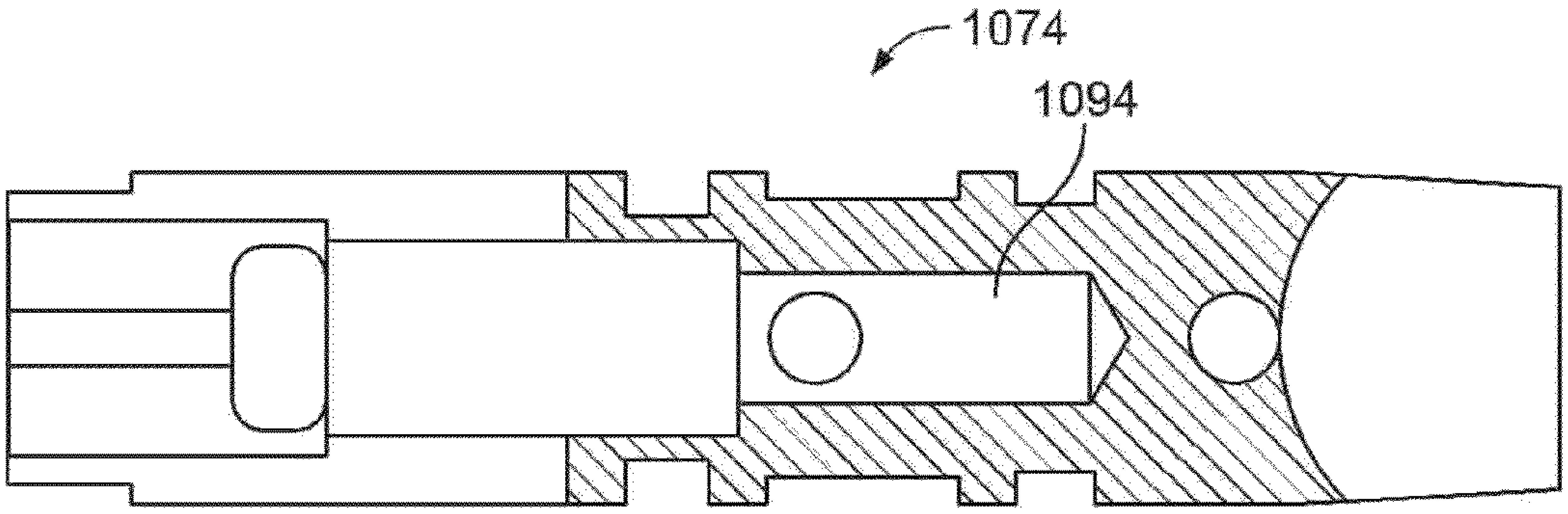


FIG. 38

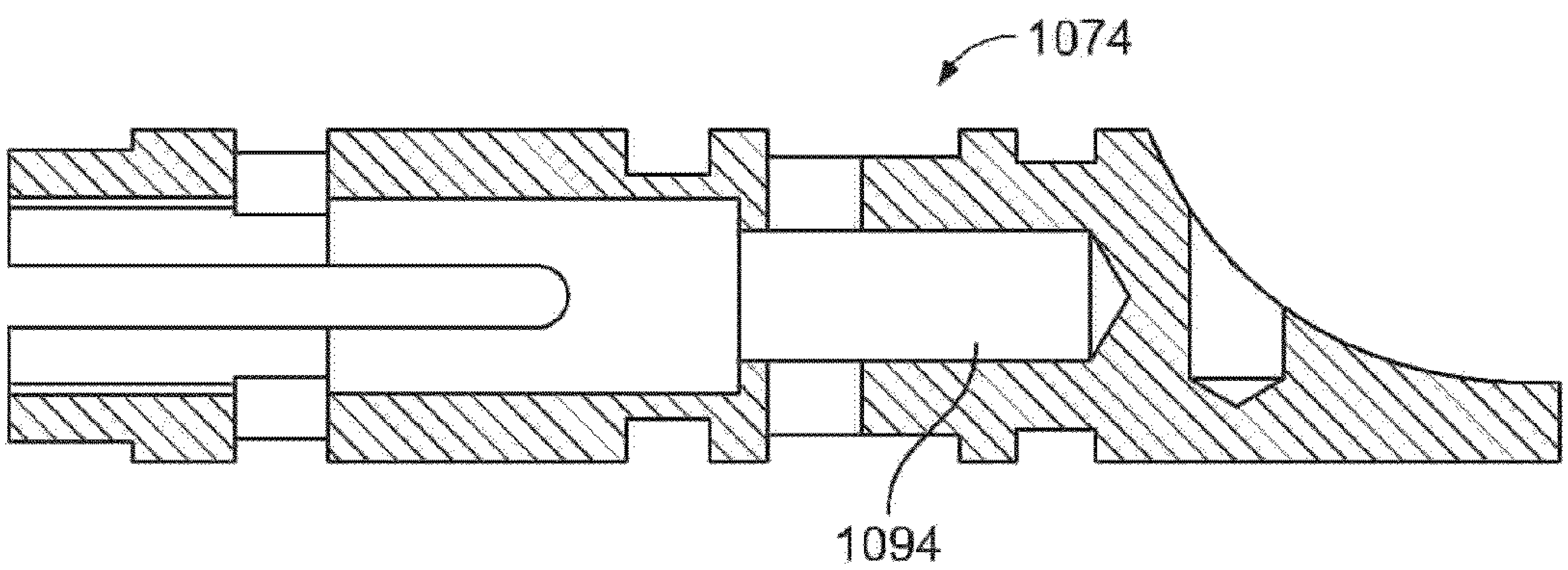


FIG. 39

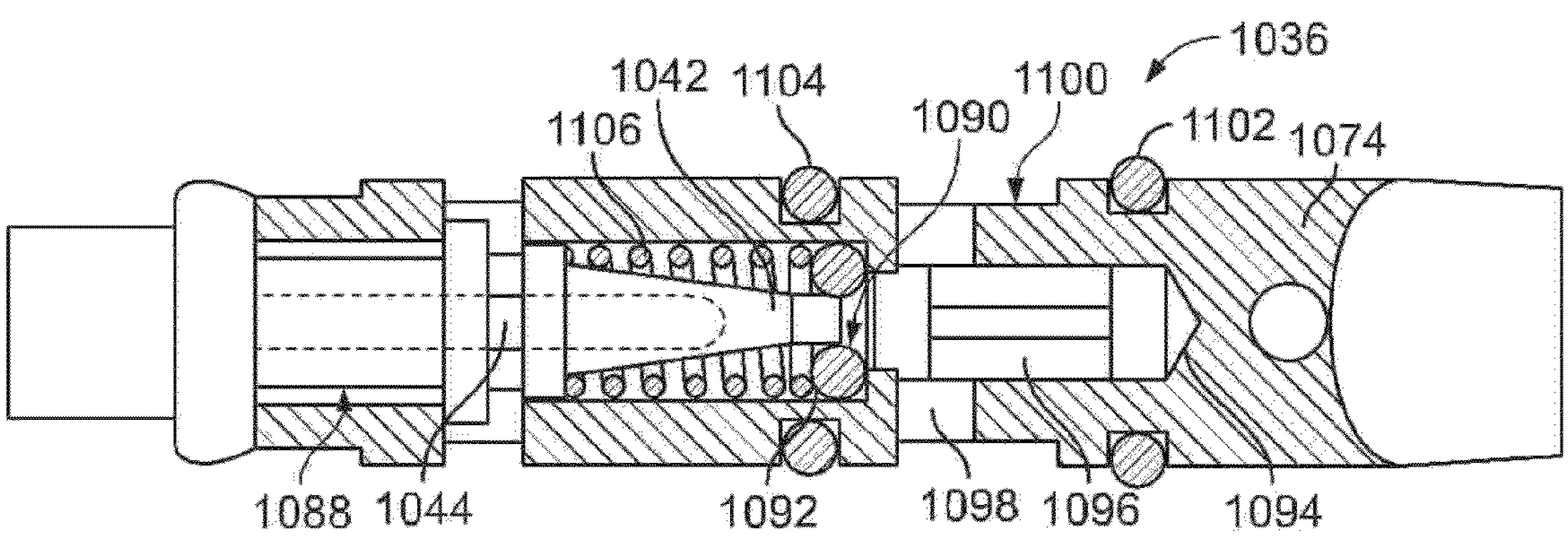
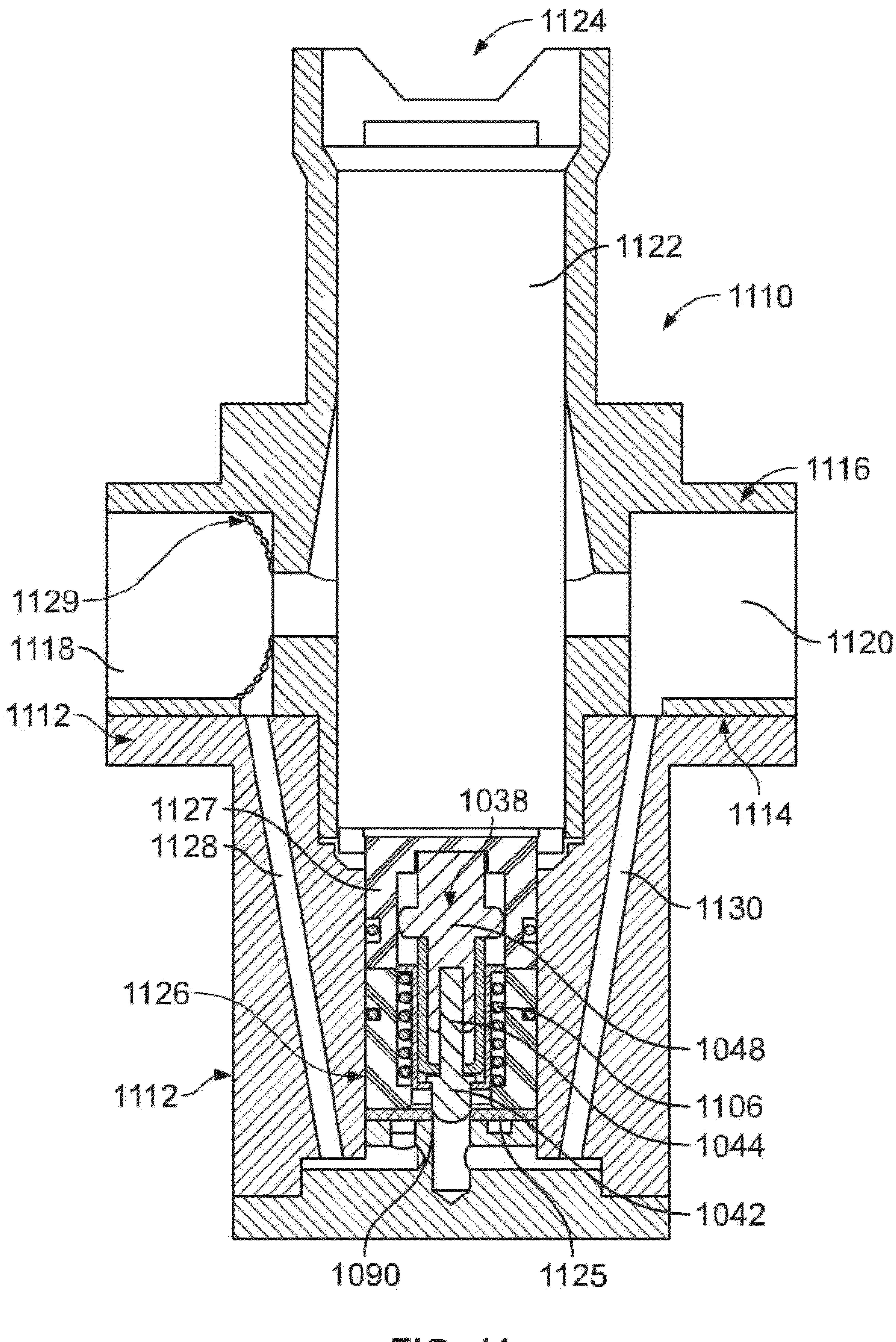


FIG. 40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1120
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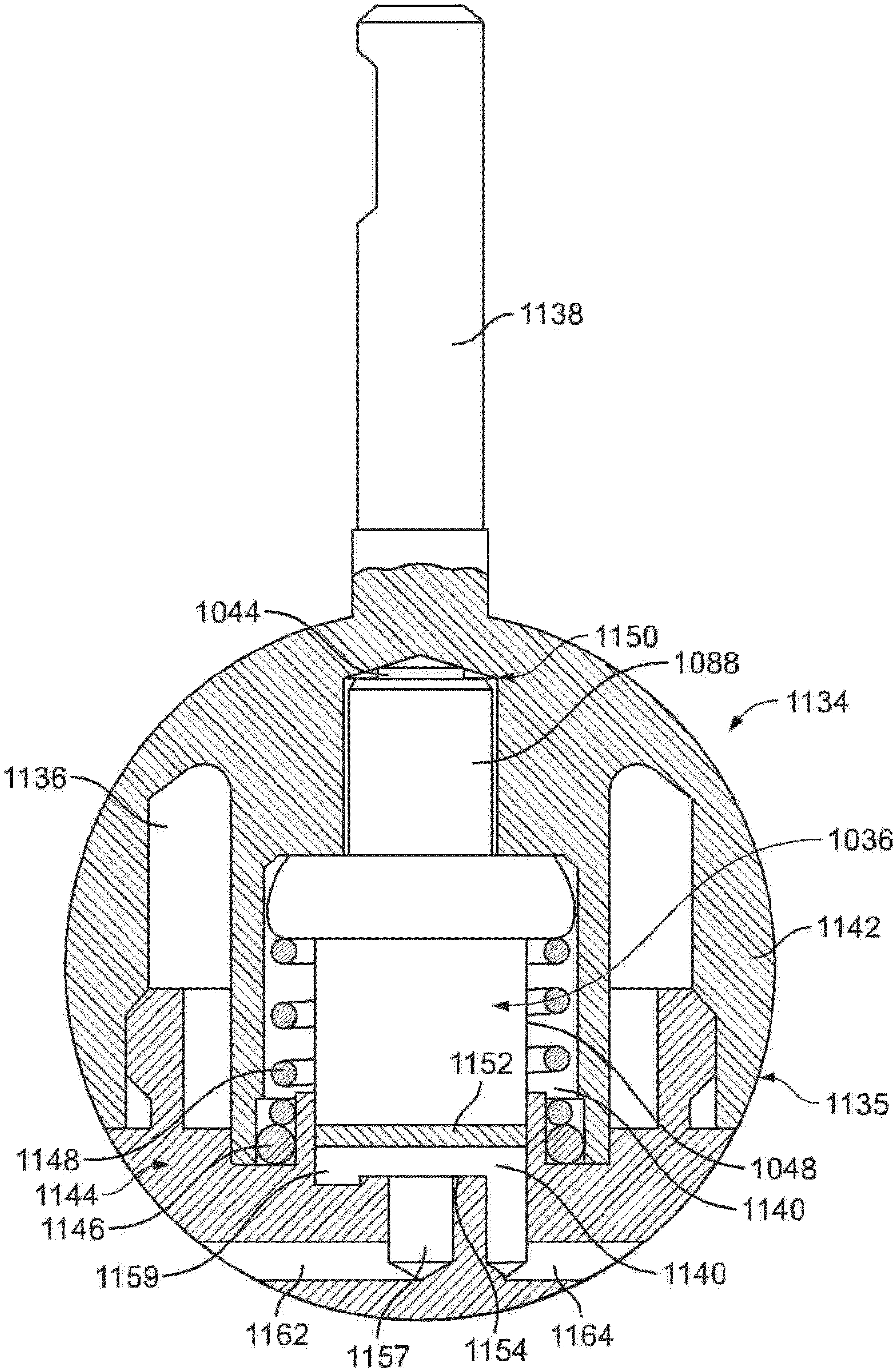
1112
1106
1044
1042
1090
1125

FIG. 41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1088
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1157
1154
1164

FIG. 42

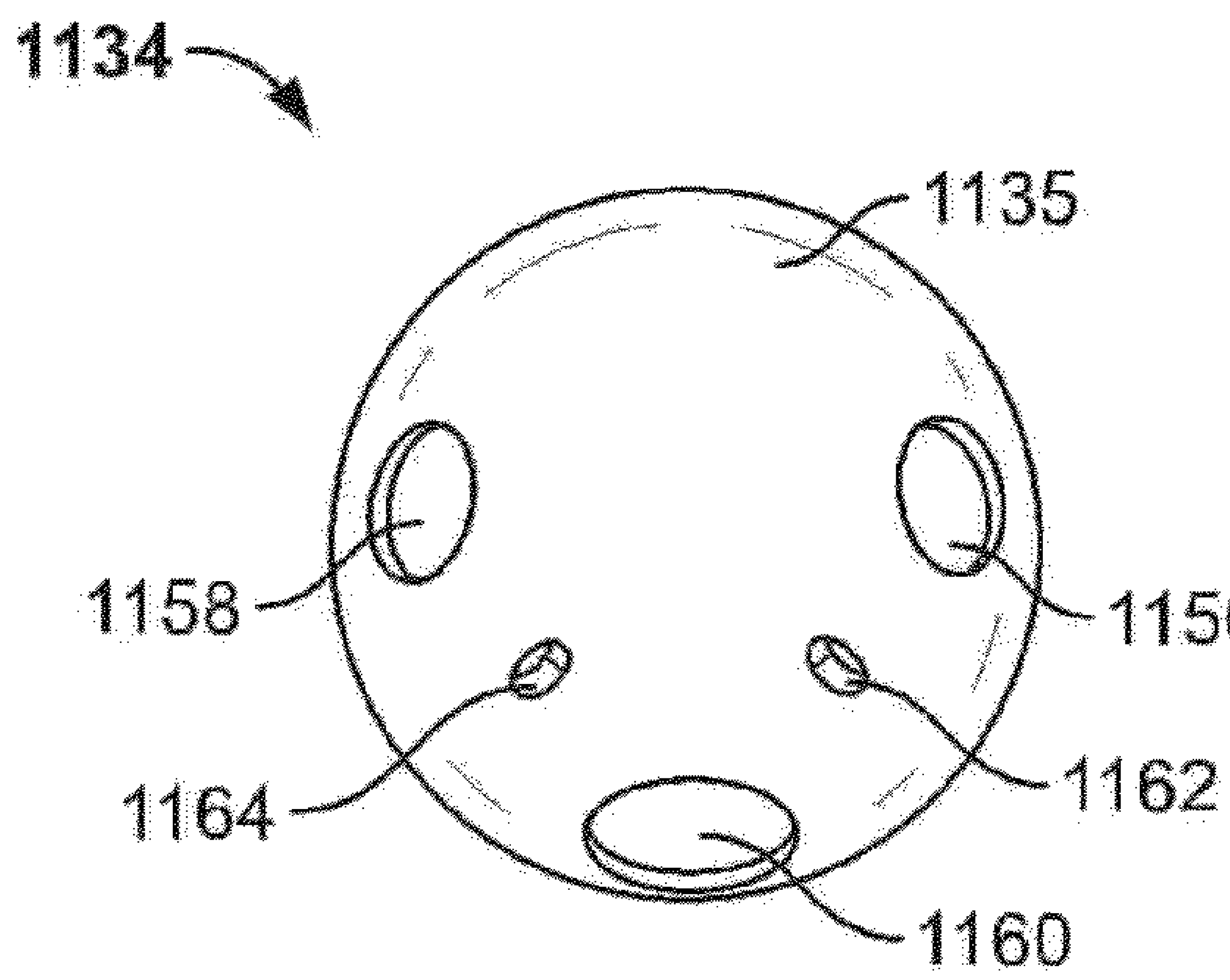


FIG. 43

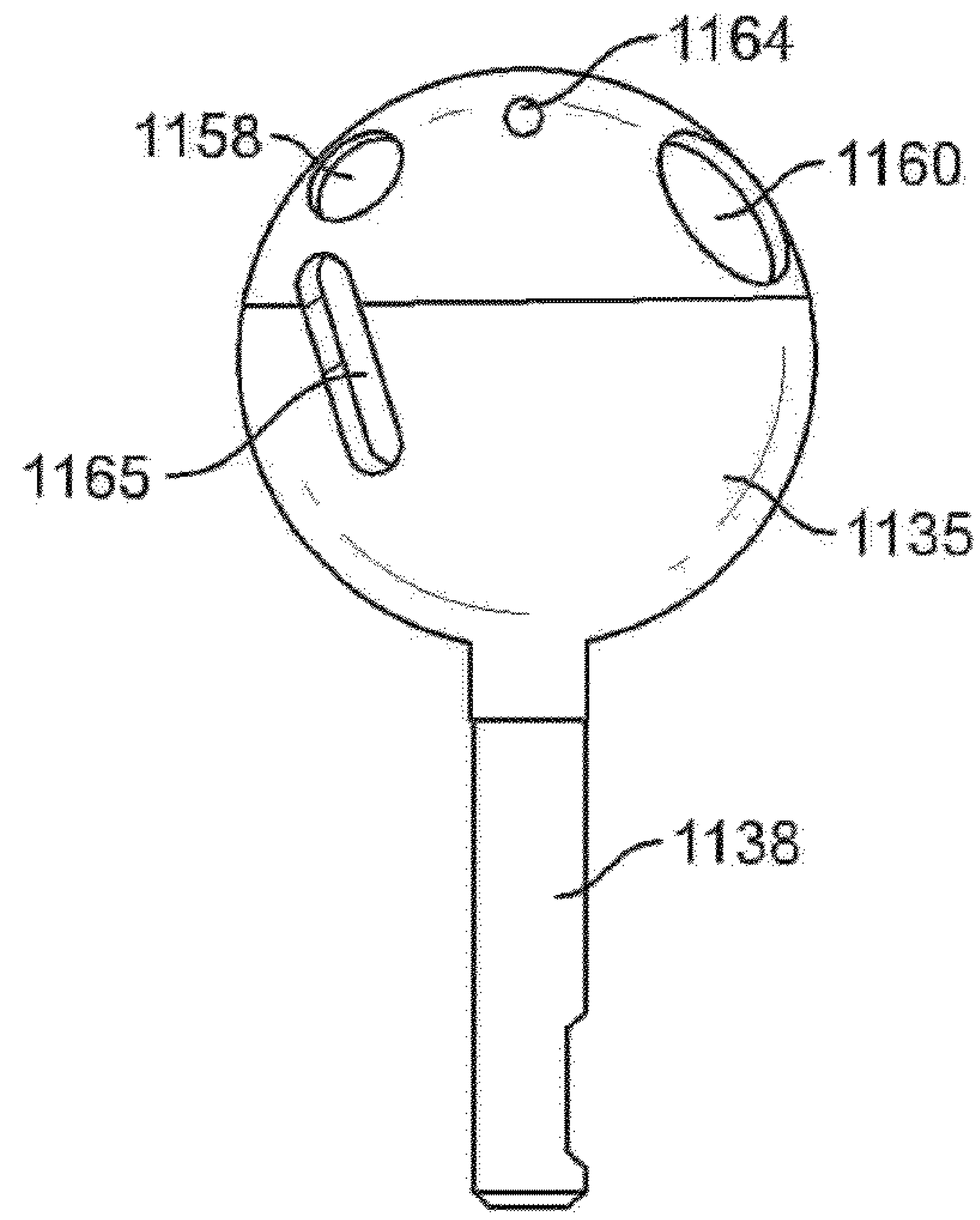


FIG. 44

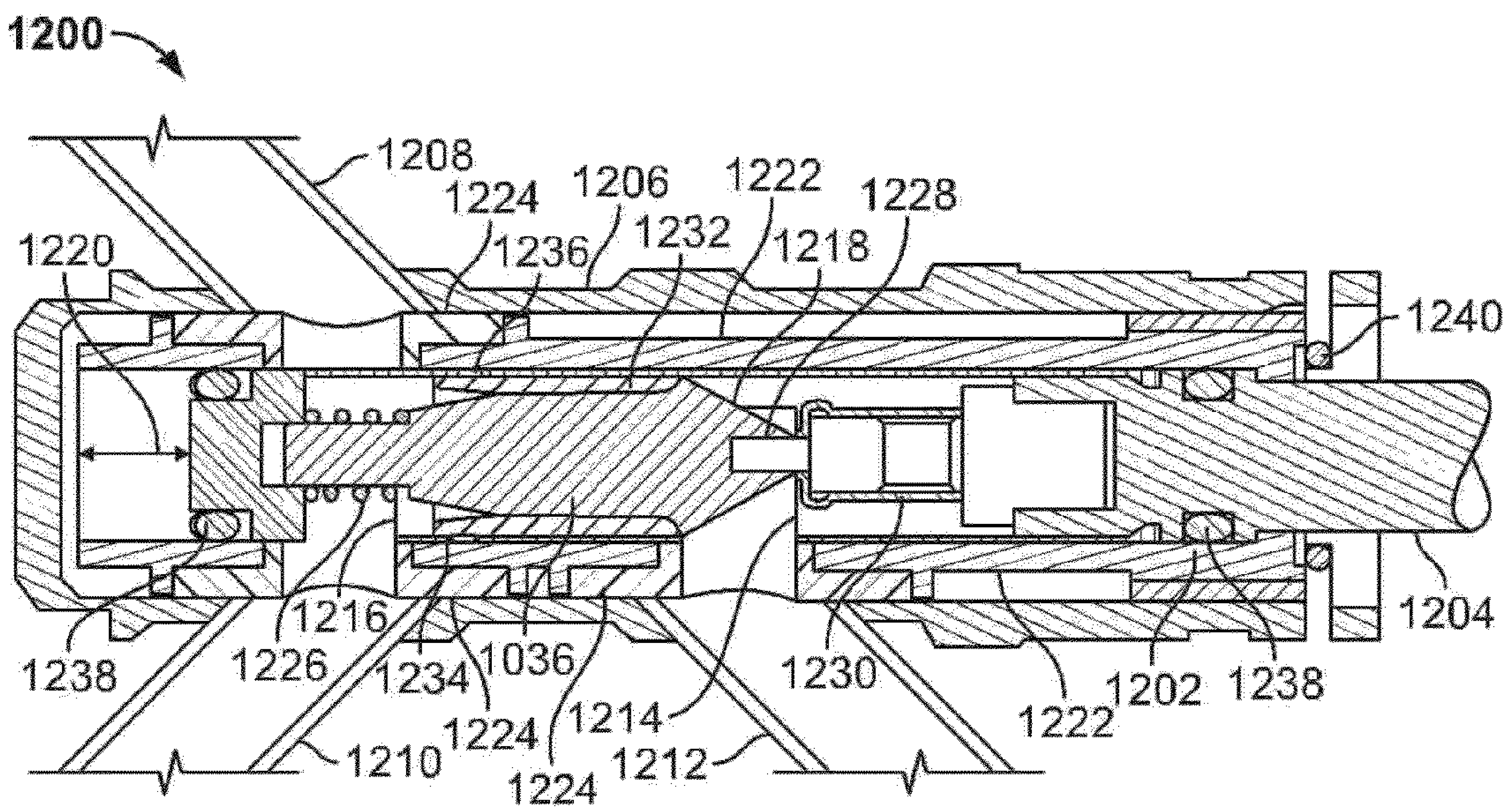
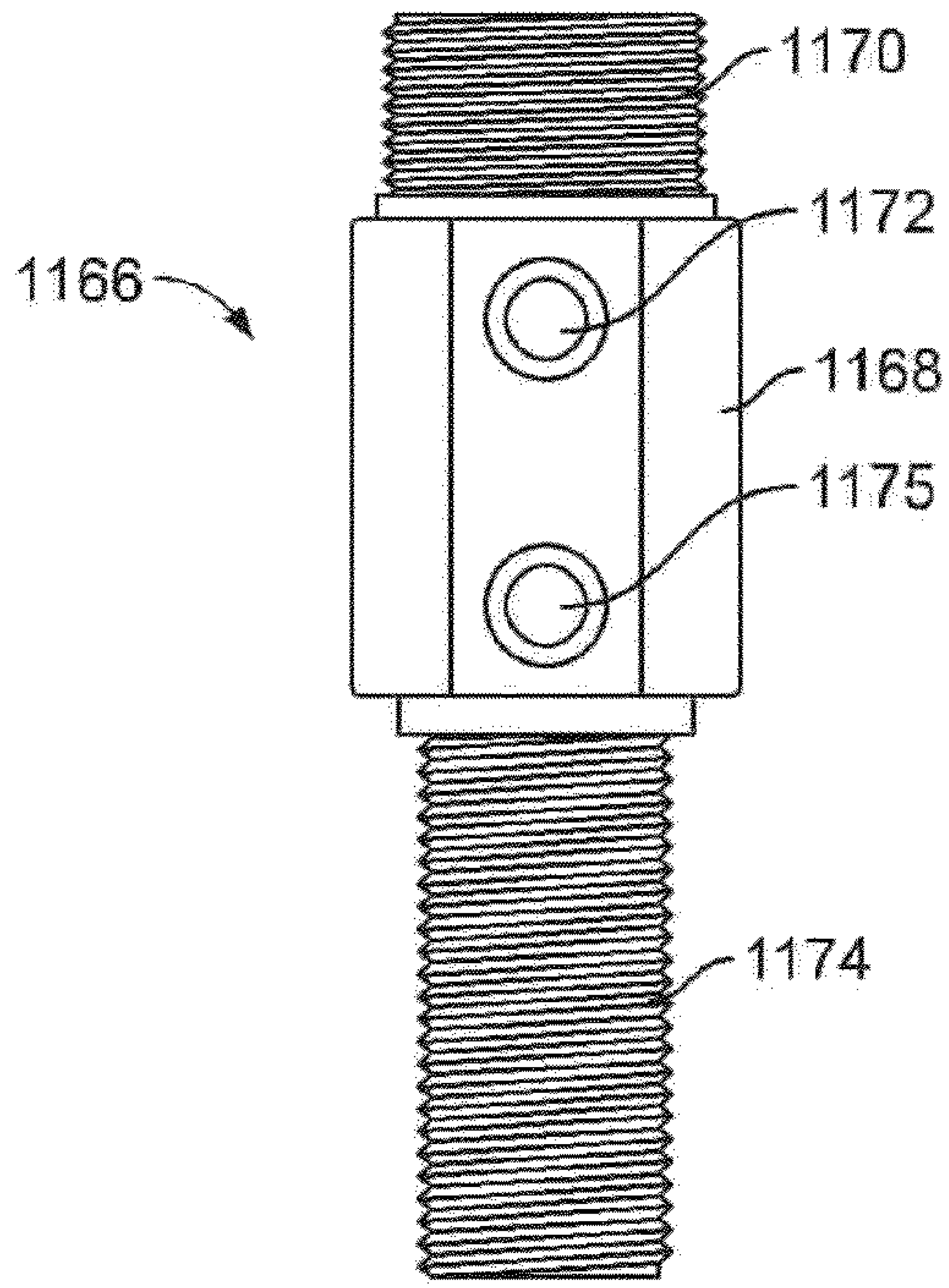
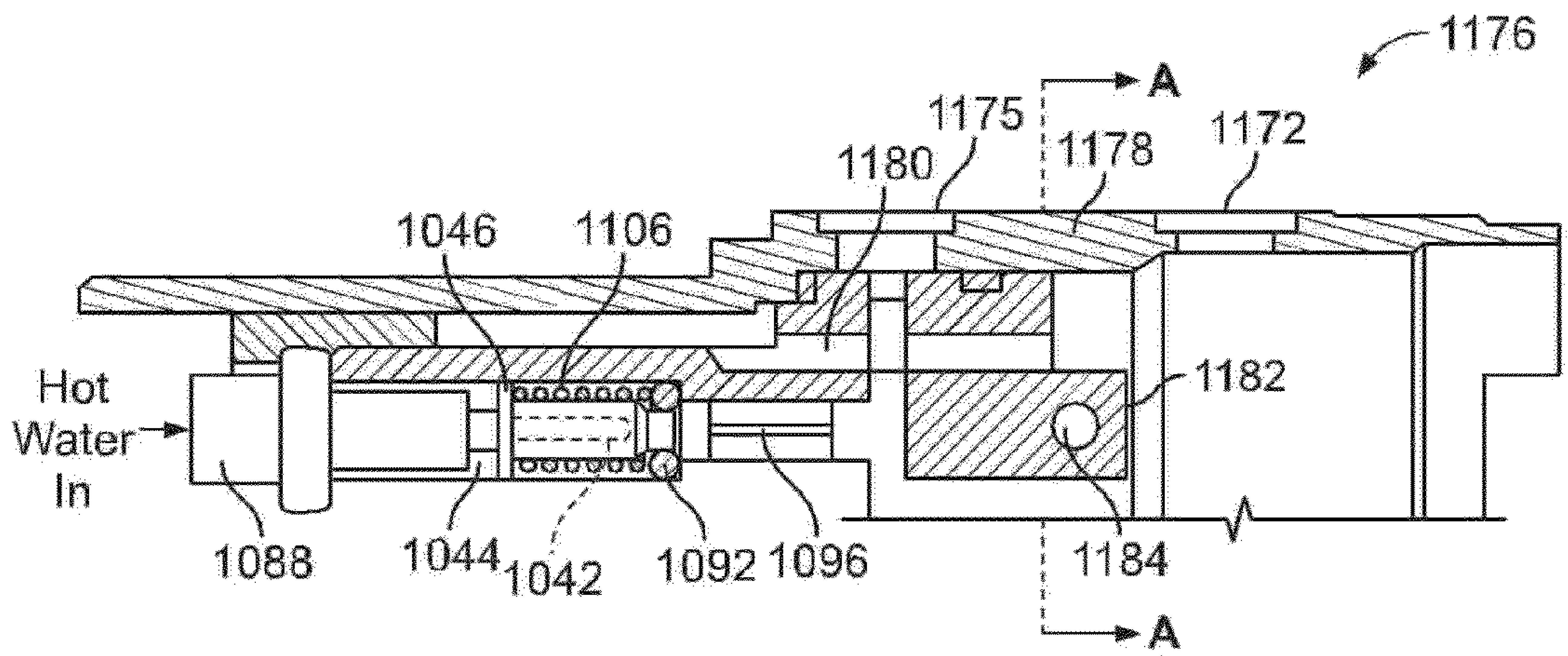


FIG. 45



1170
1172
1166
1168
1175
1174

FIG. 46



1176
A
1175
1172
1180
1178
1046
1106
Hot
Water
In
1182
1088
1044
1042
1092
1096
1184
A

FIG. 47

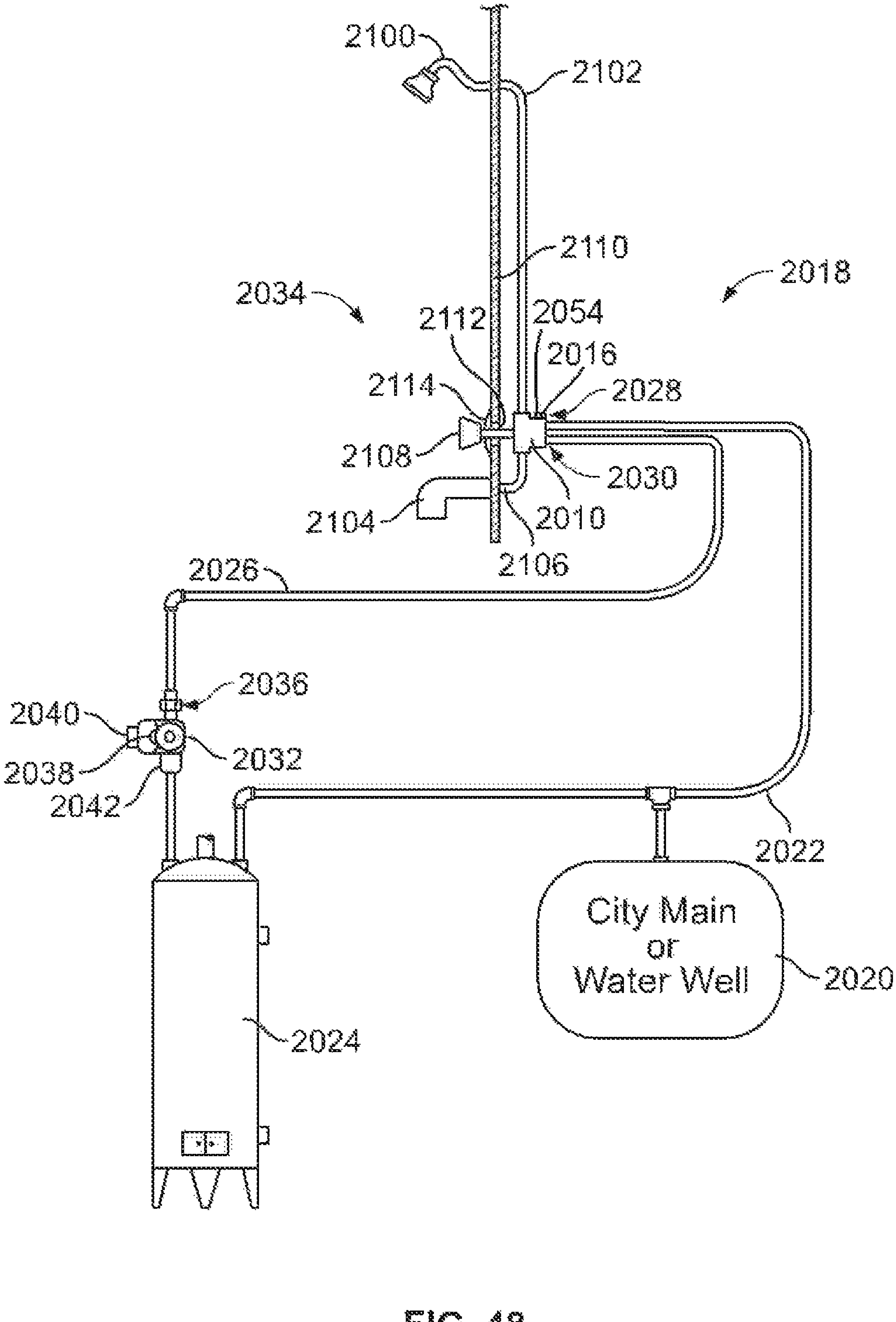

2100
2102
2110
2018
2034
2112
2054
2016
2114
2028
2108
2030
2104
2010
2106
2026
2036
2040
2032
2038
2042
2022
City Main
or
Water Well
2020
2024

FIG. 48

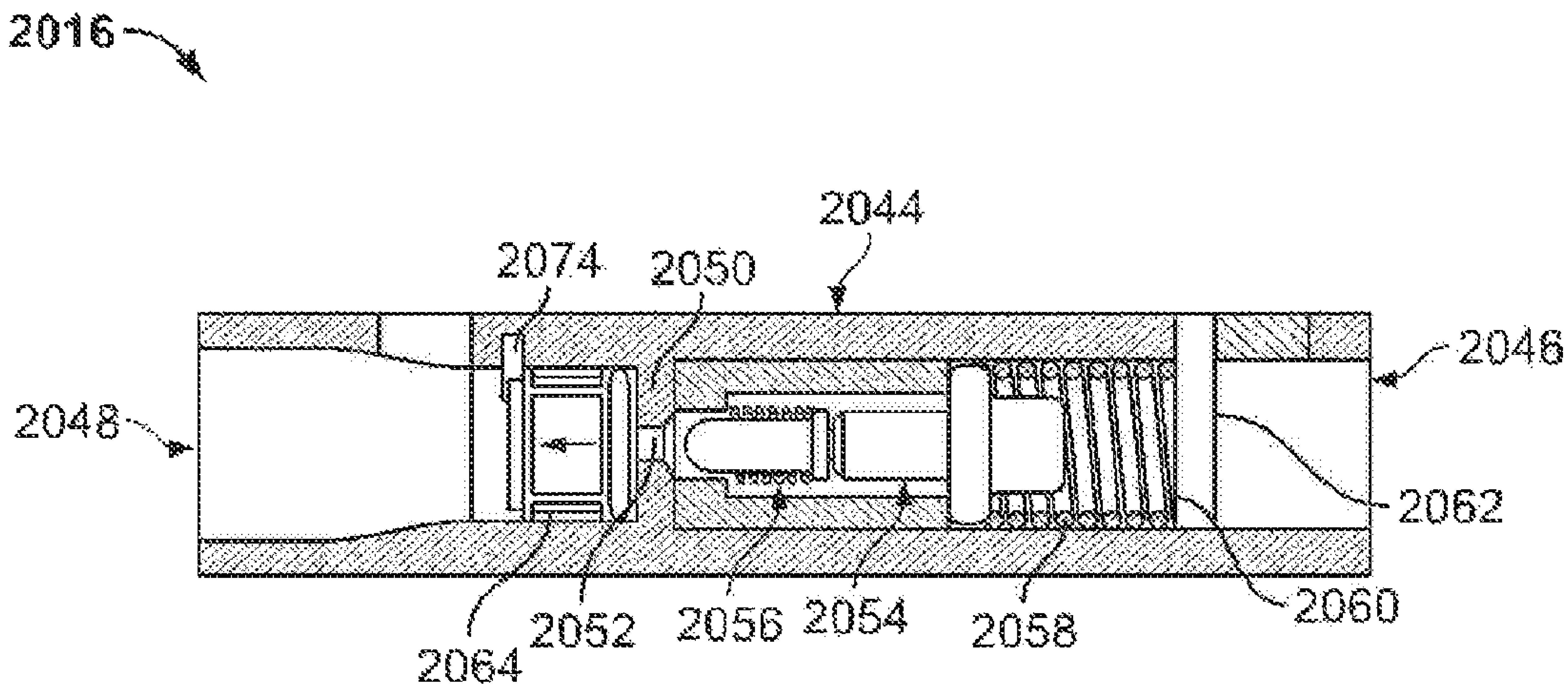


FIG. 49

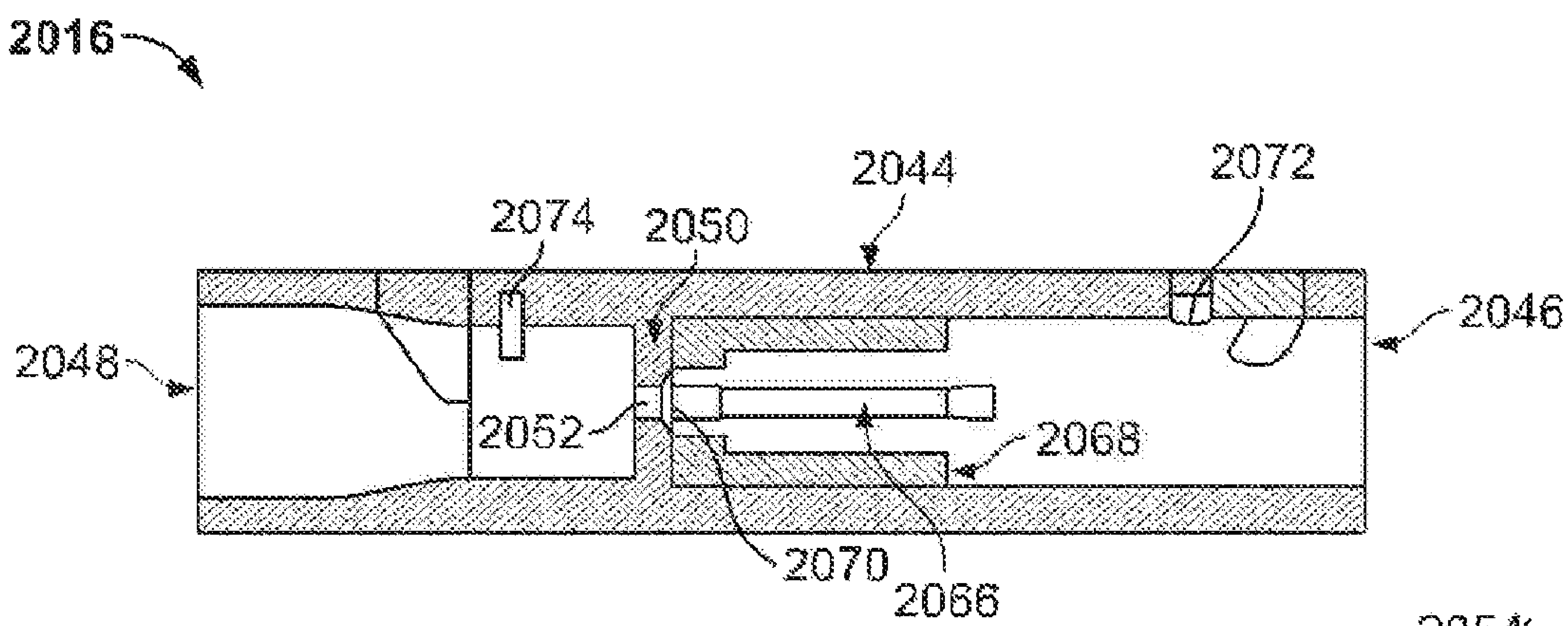


FIG. 50

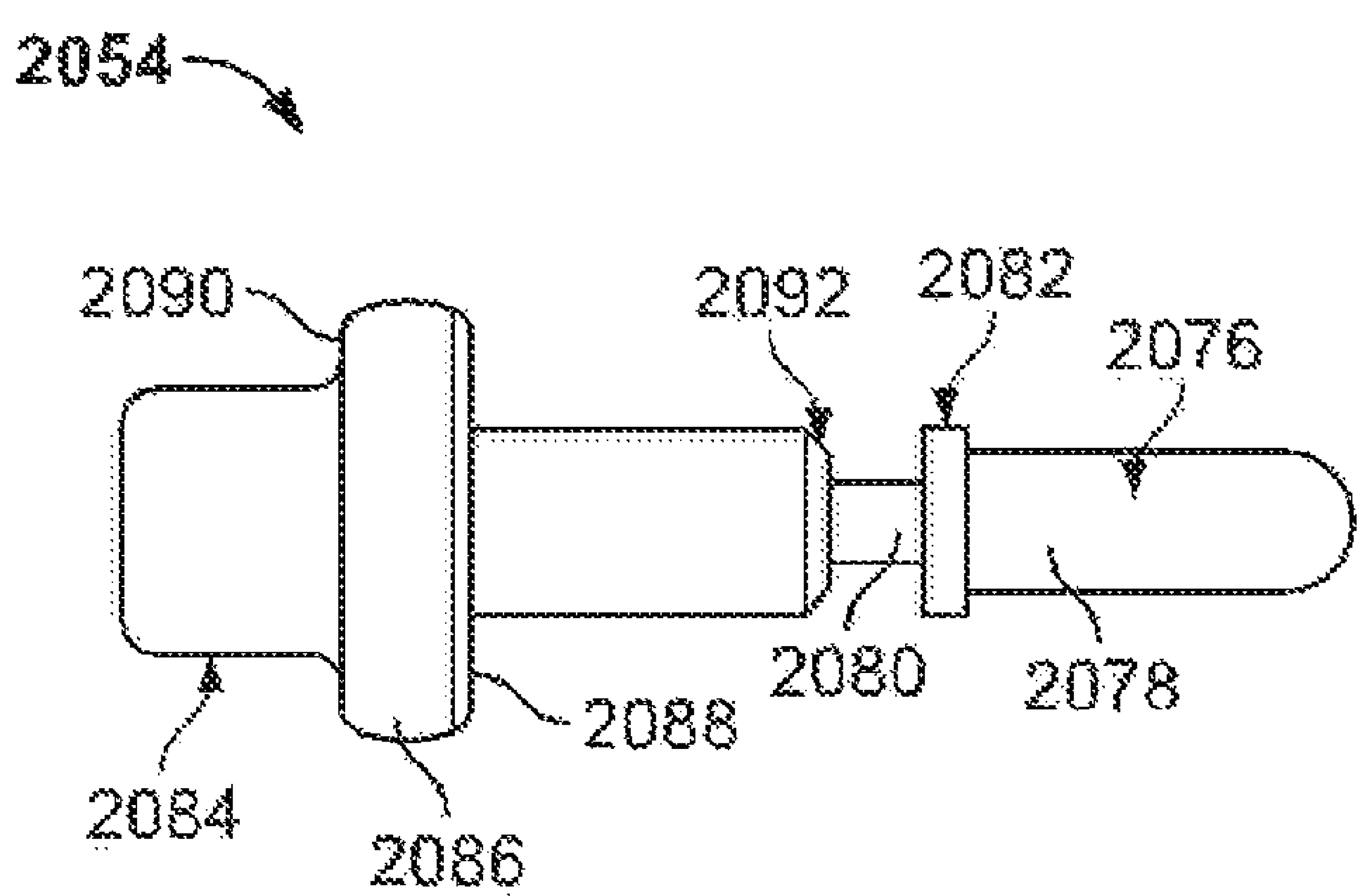


FIG. 51

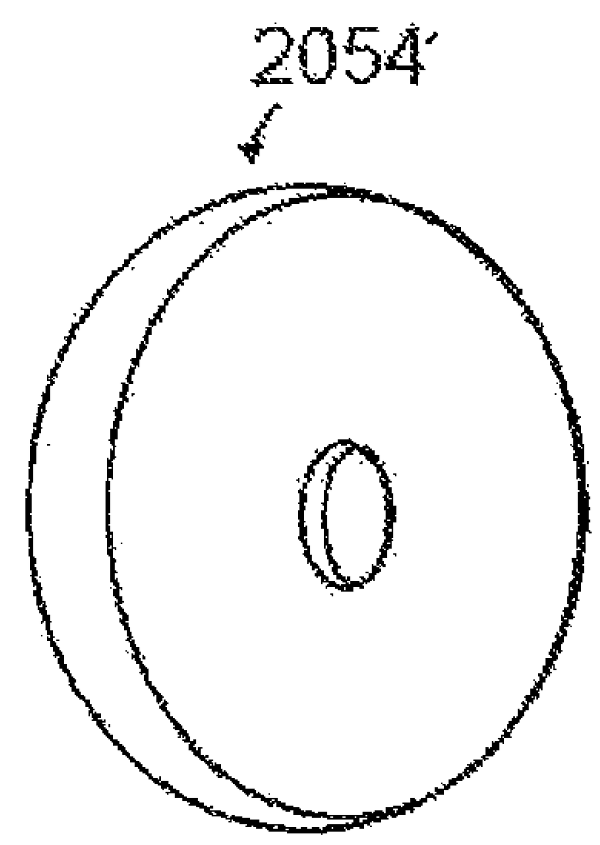
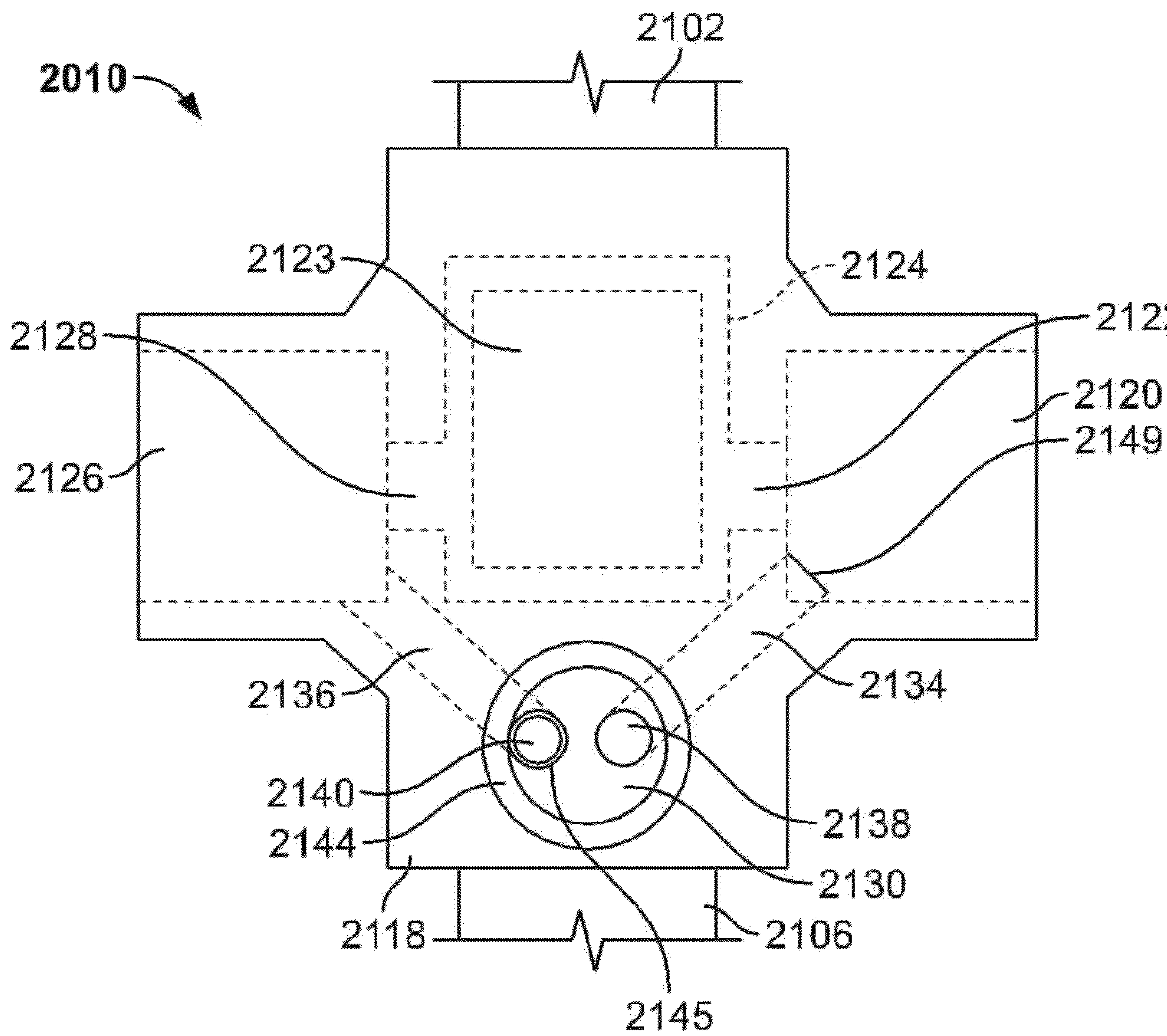


FIG. 51A



2010
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FIG. 52

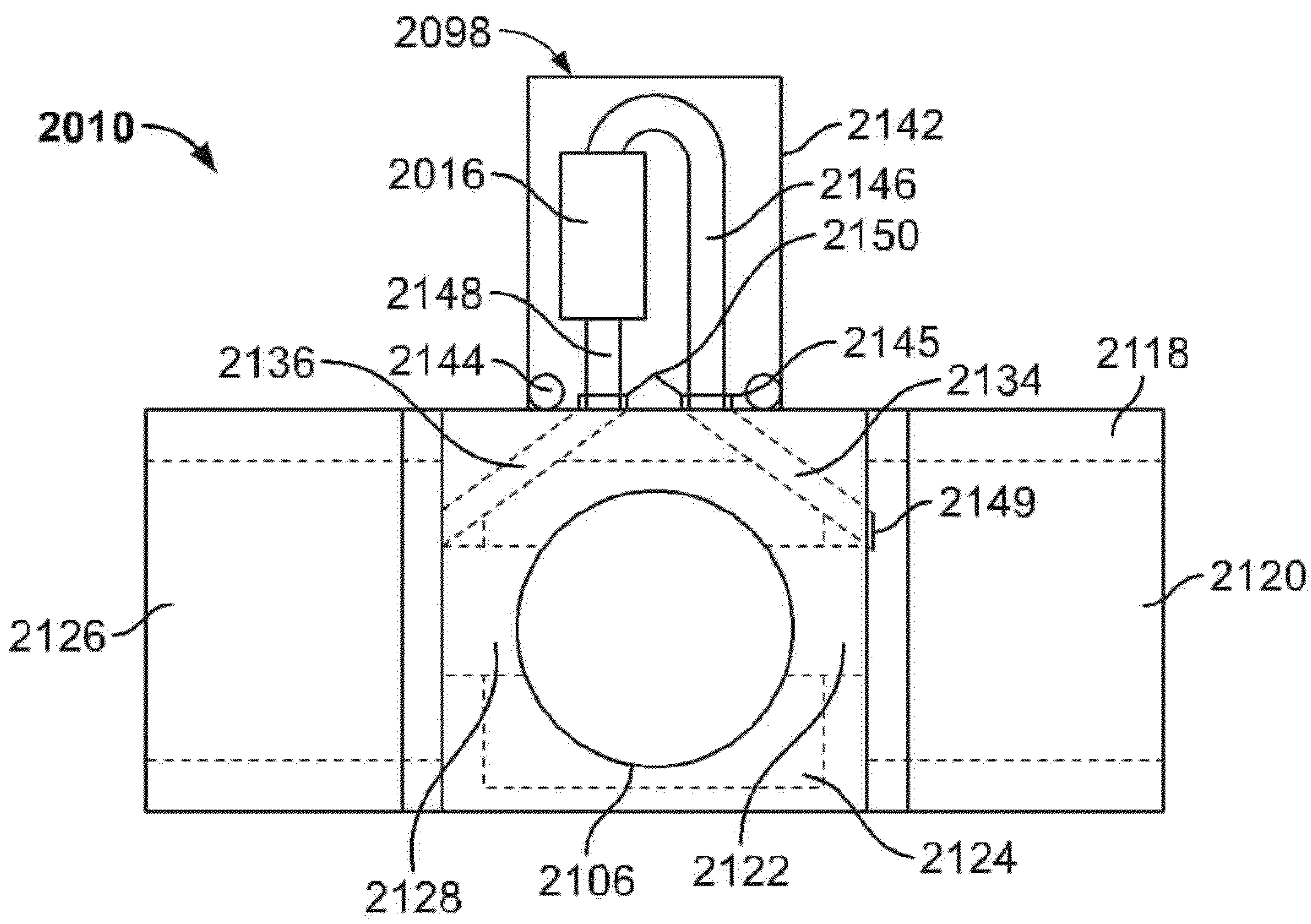

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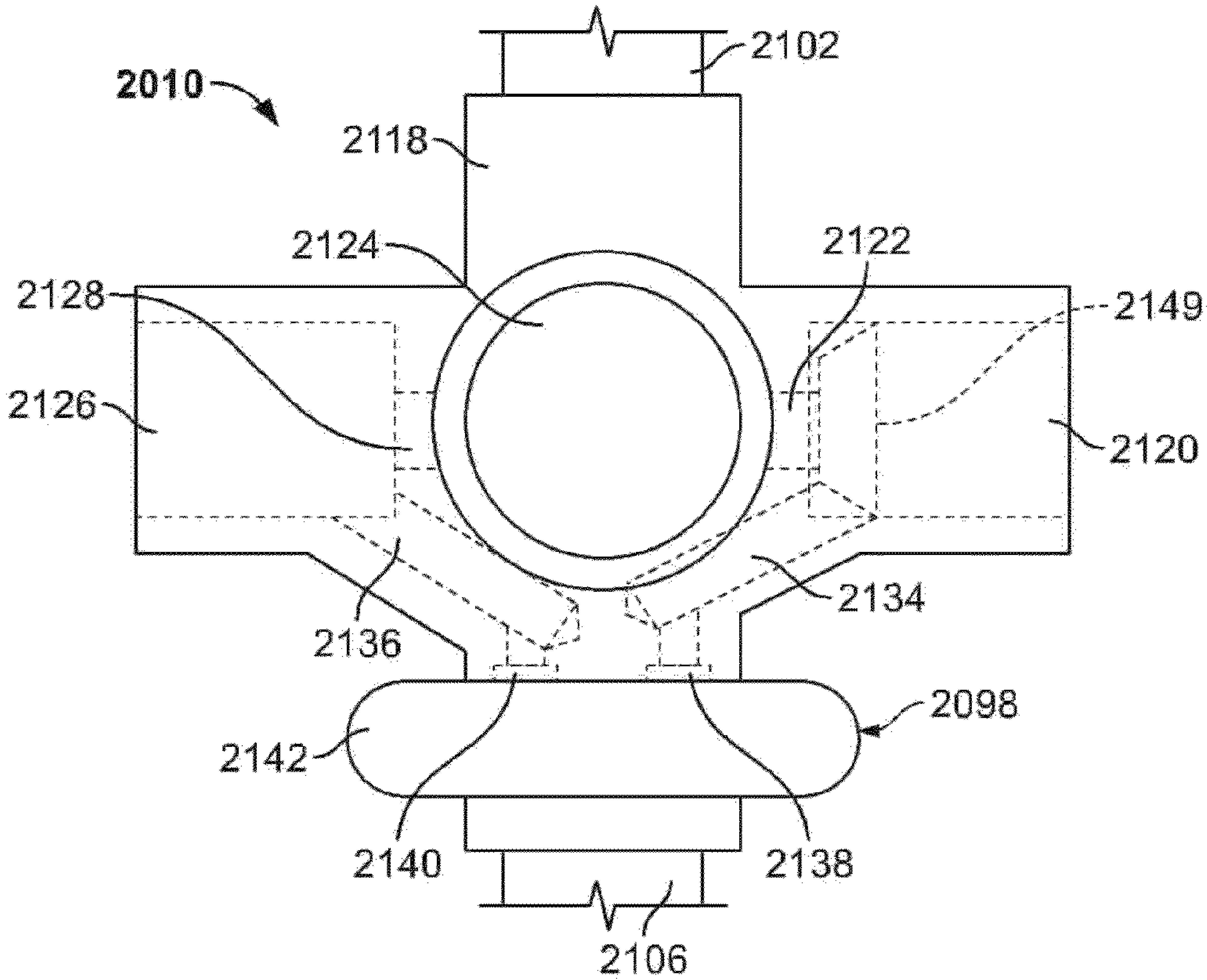
FIG. 53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2136
2098
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2138
2106

FIG. 54

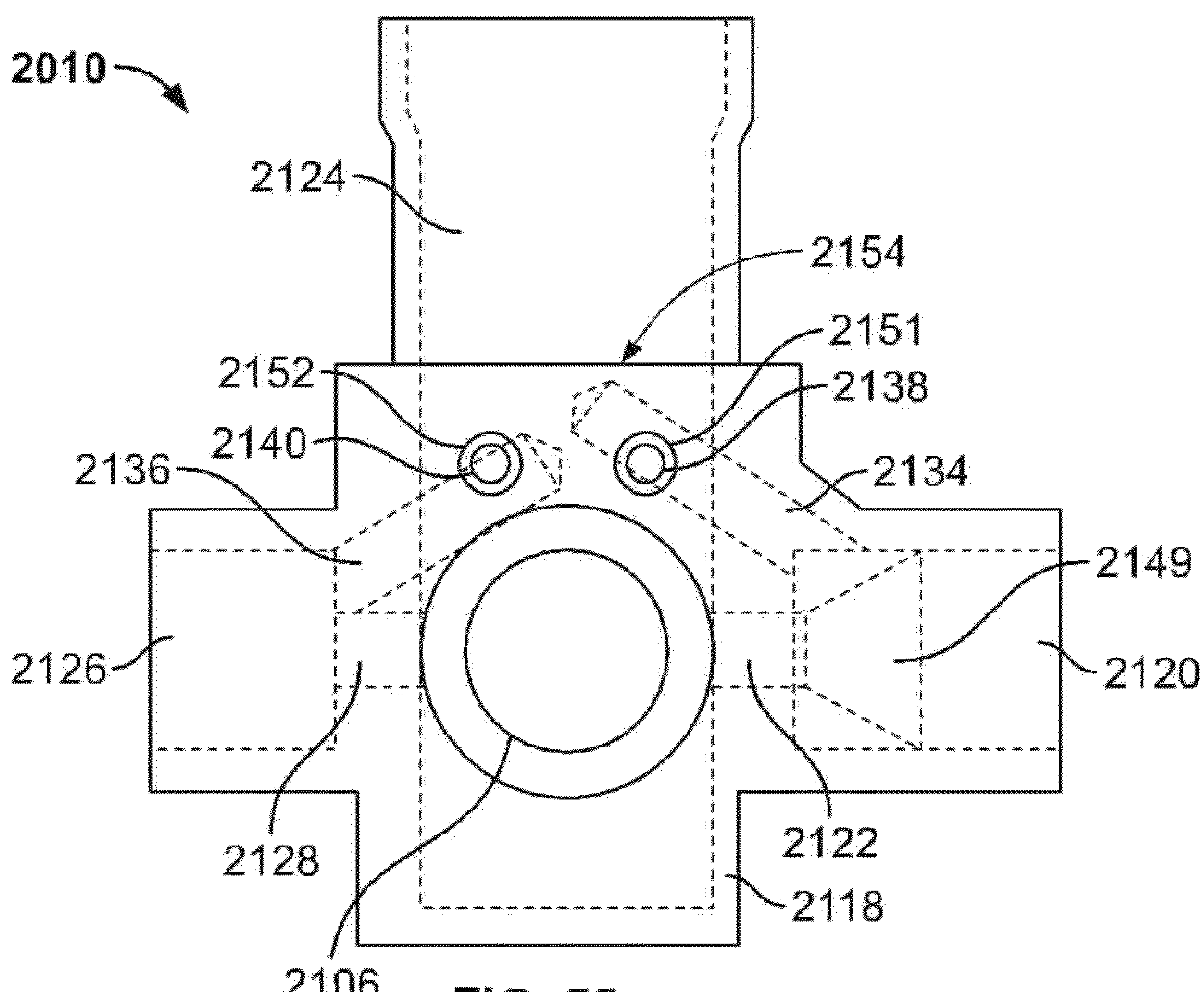
2010
2124
2154
2151
2152
2138
2140
2136
2134
2149
2126
2120
2128
2122
2118
2106

FIG. 55

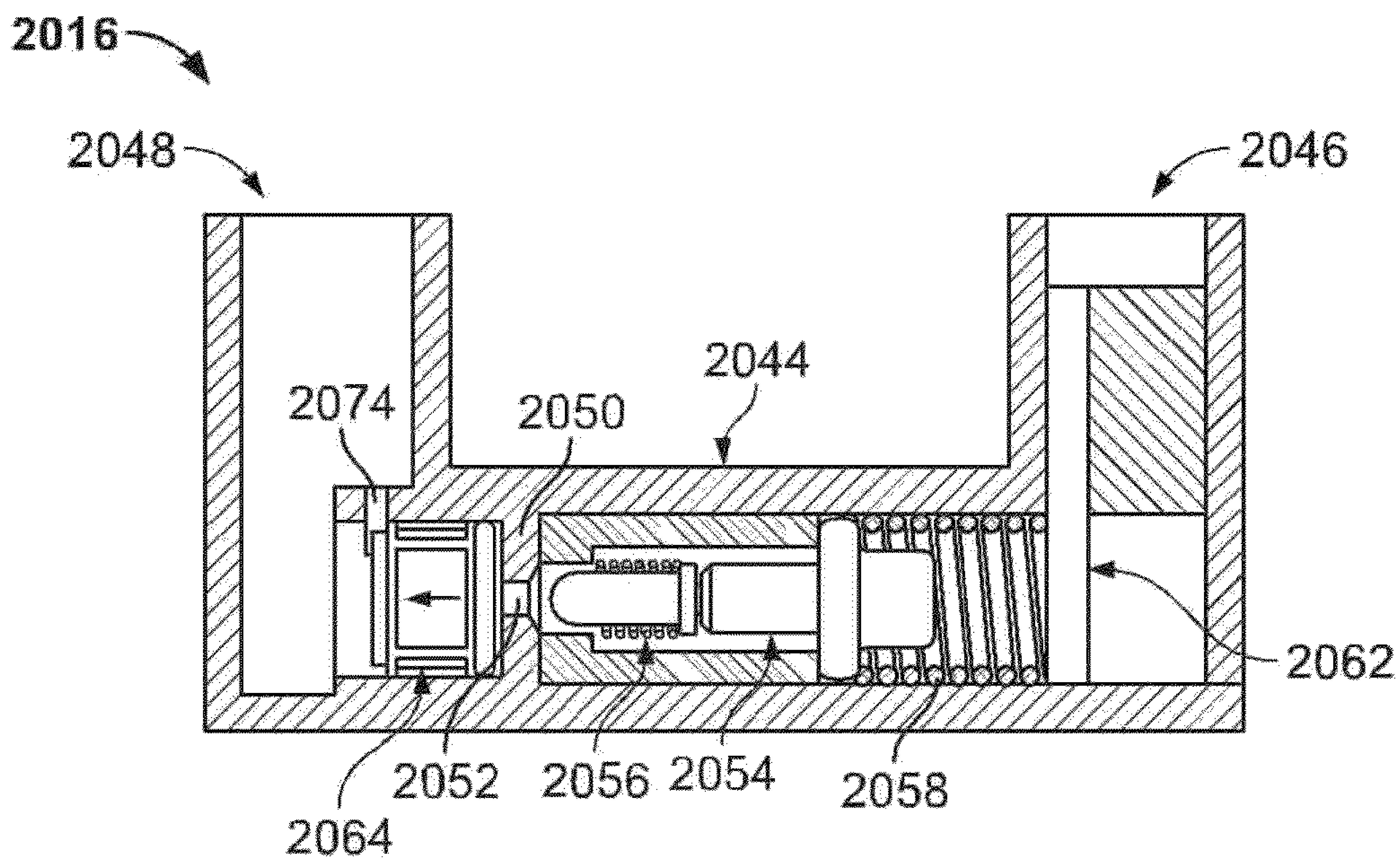
2016
2048
2046
2044
2074
2050
2062
2064
2052
2056
2054
2058

FIG. 56

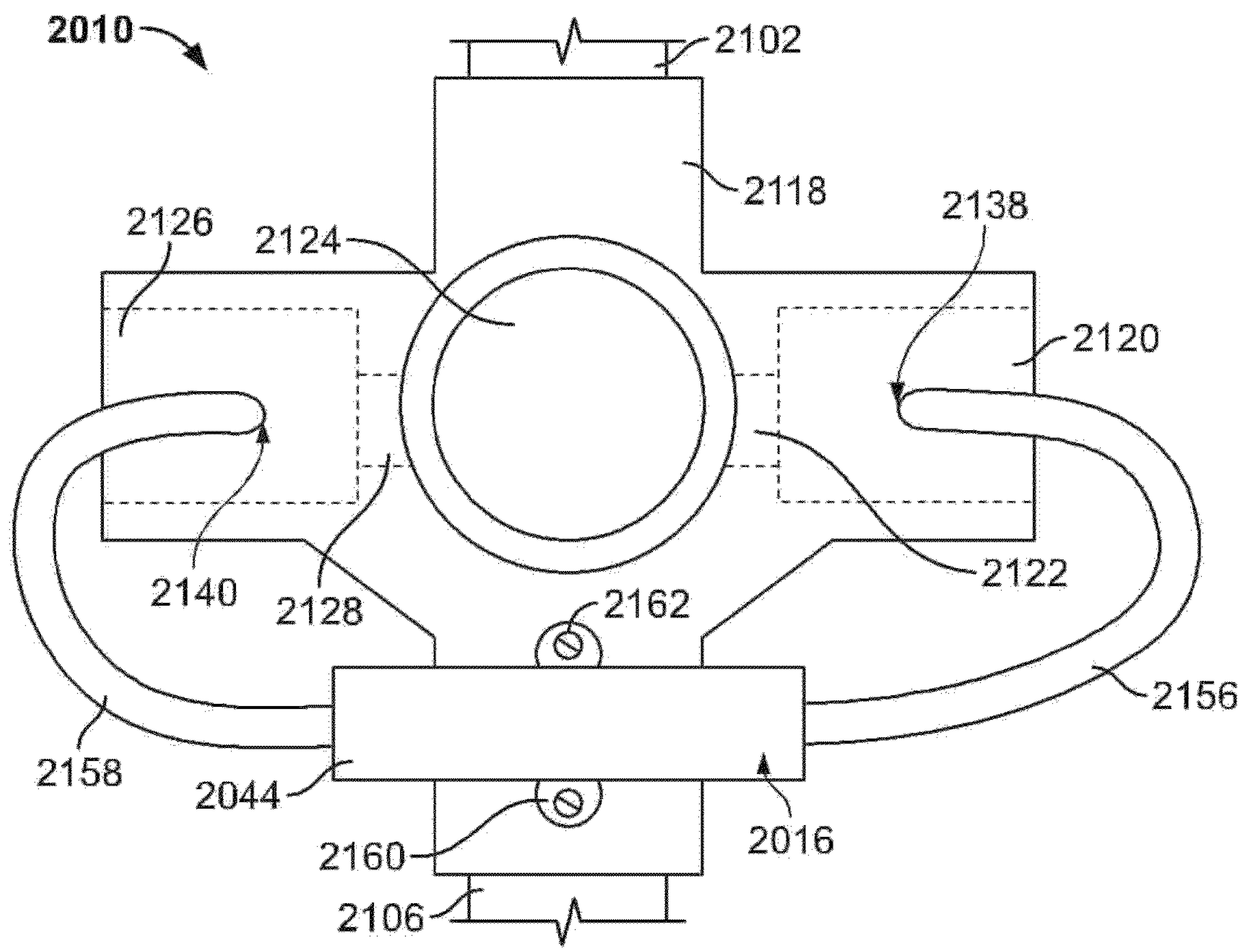
2010
2102
2118
2126
2124
2138
2120
2140
2128
2122
2162
2156
2158
2044
2016
2160
2106

FIG. 57

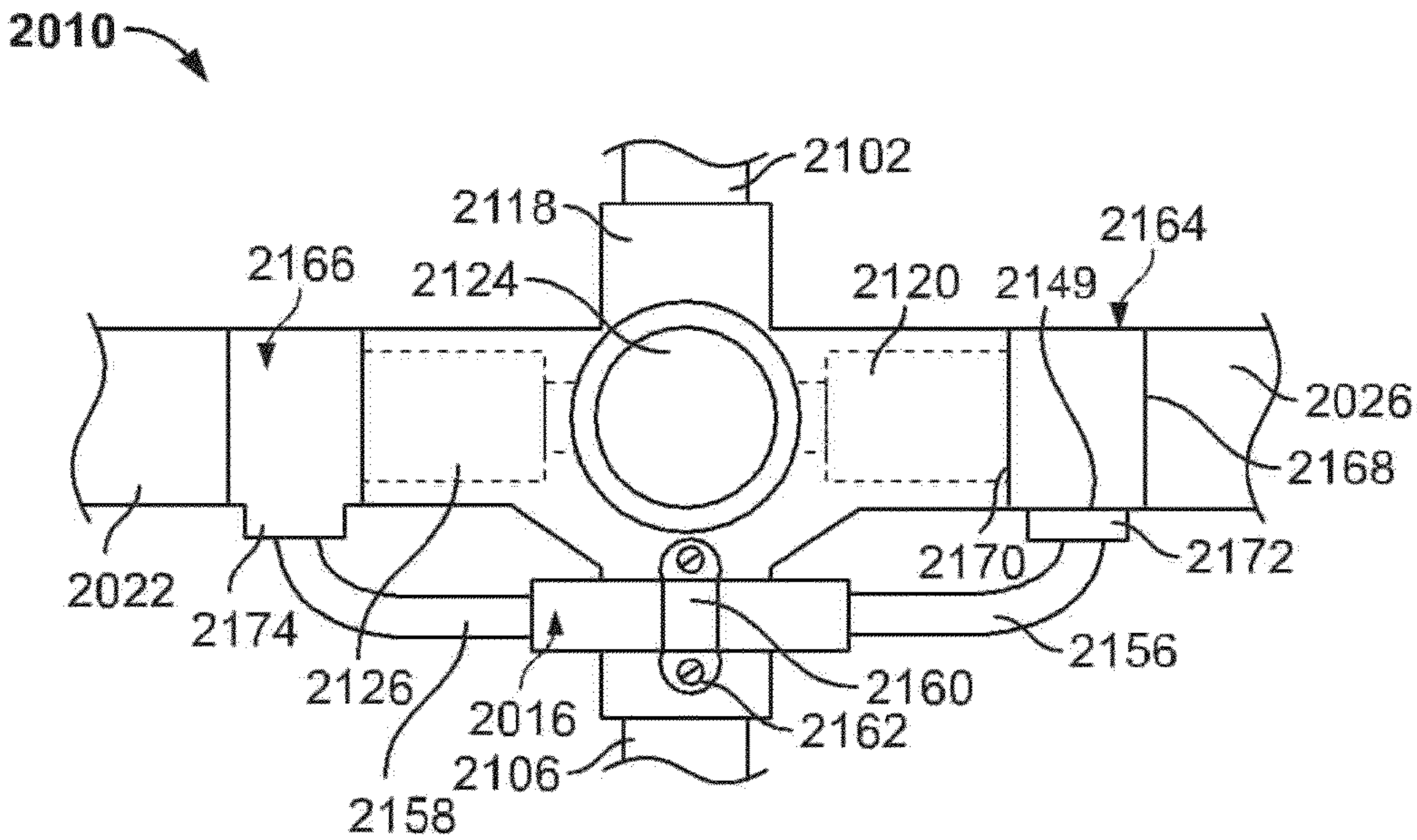
2010
2102
2118
2164
2166
2124
2120
2149
2026
2168
2022
2170
2172
2174
2156
2126
2160
2016
2162
2106
2158

FIG. 58

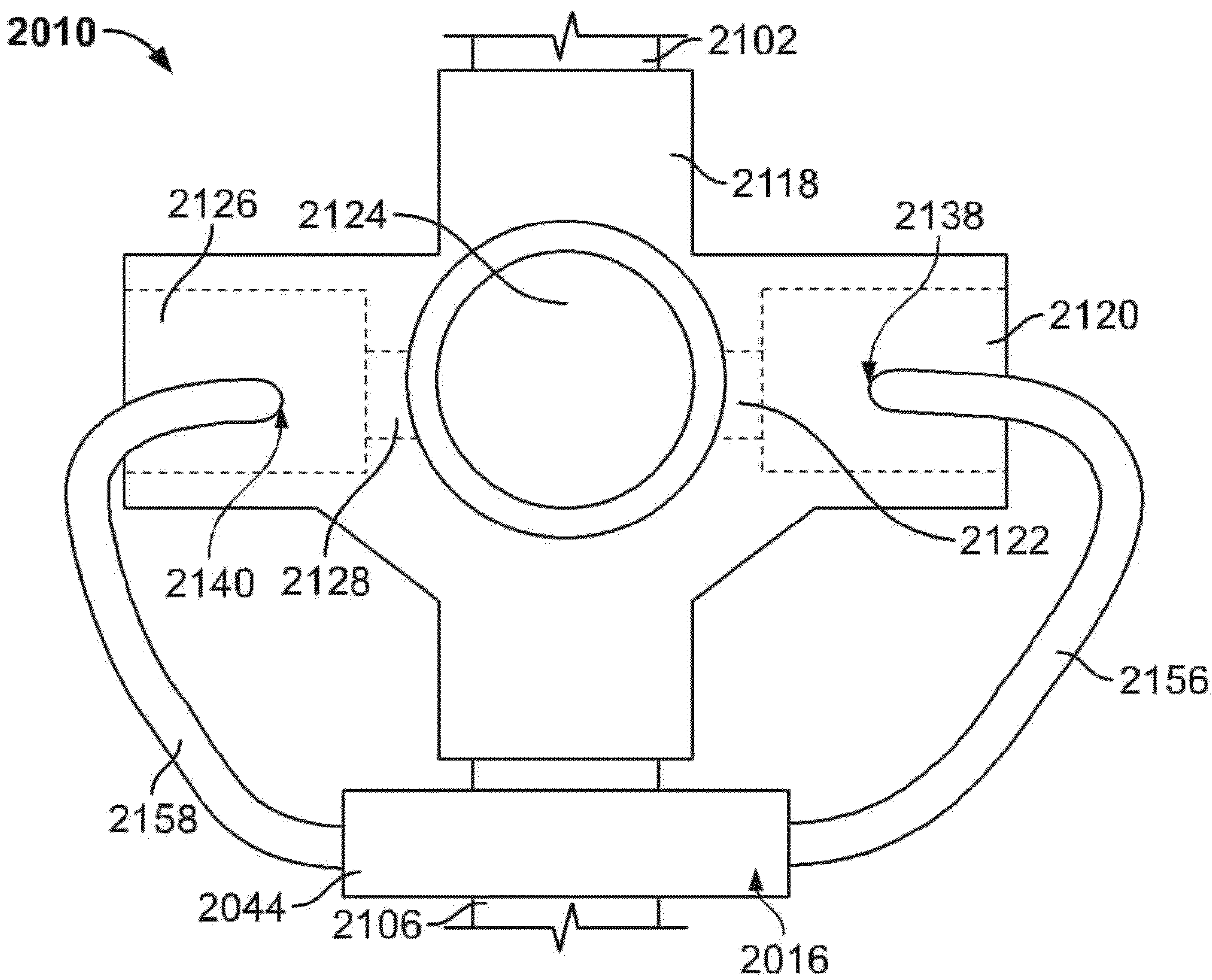
2010
2102
2118
2126
2124
2138
2120
2122
2140
2128
2156
2158
2044
2106
2016

FIG. 59

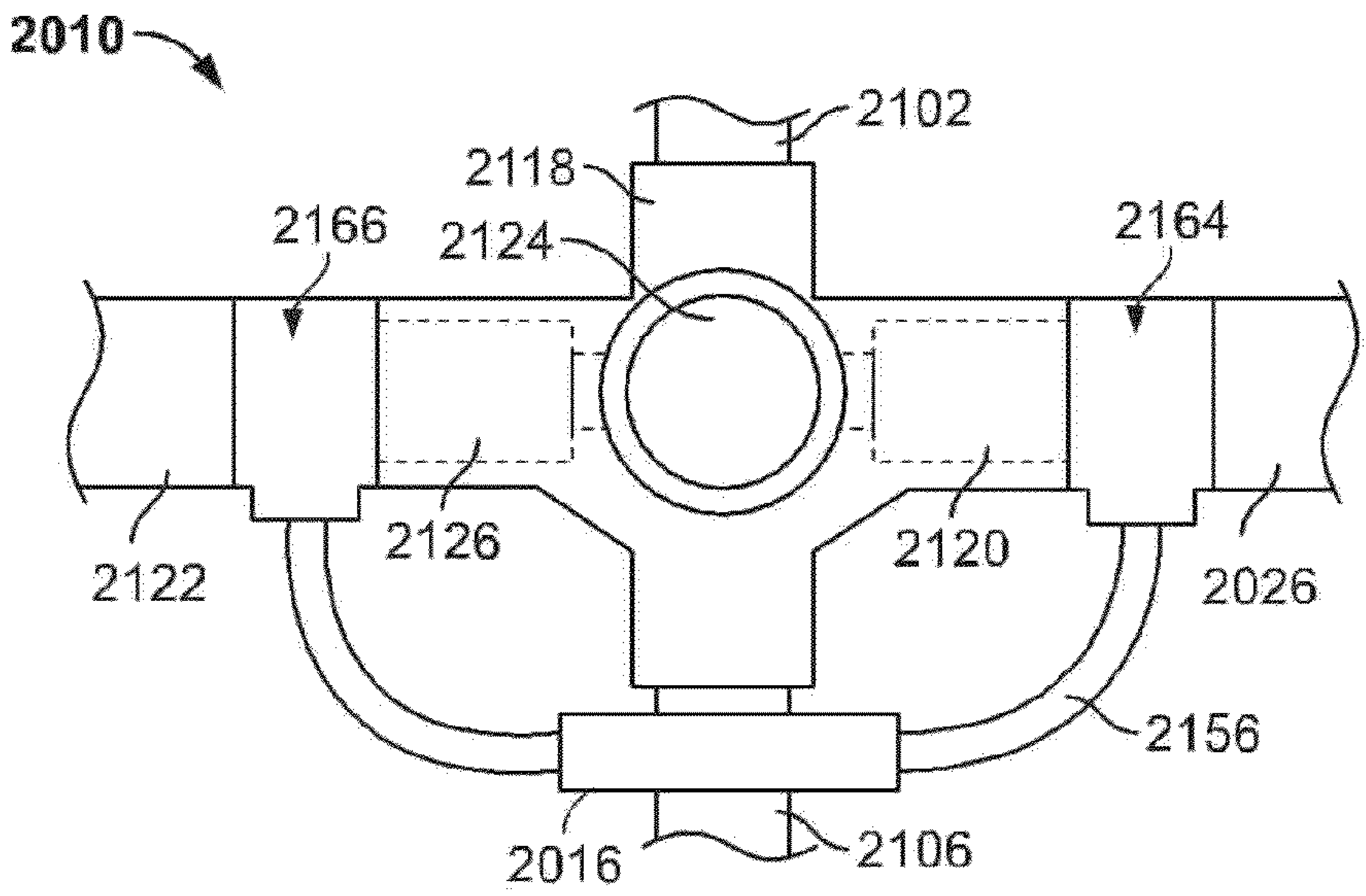
2010
2102
2118
2166
2124
2164
2122
2126
2120
2026
2156
2016
2106

FIG. 60

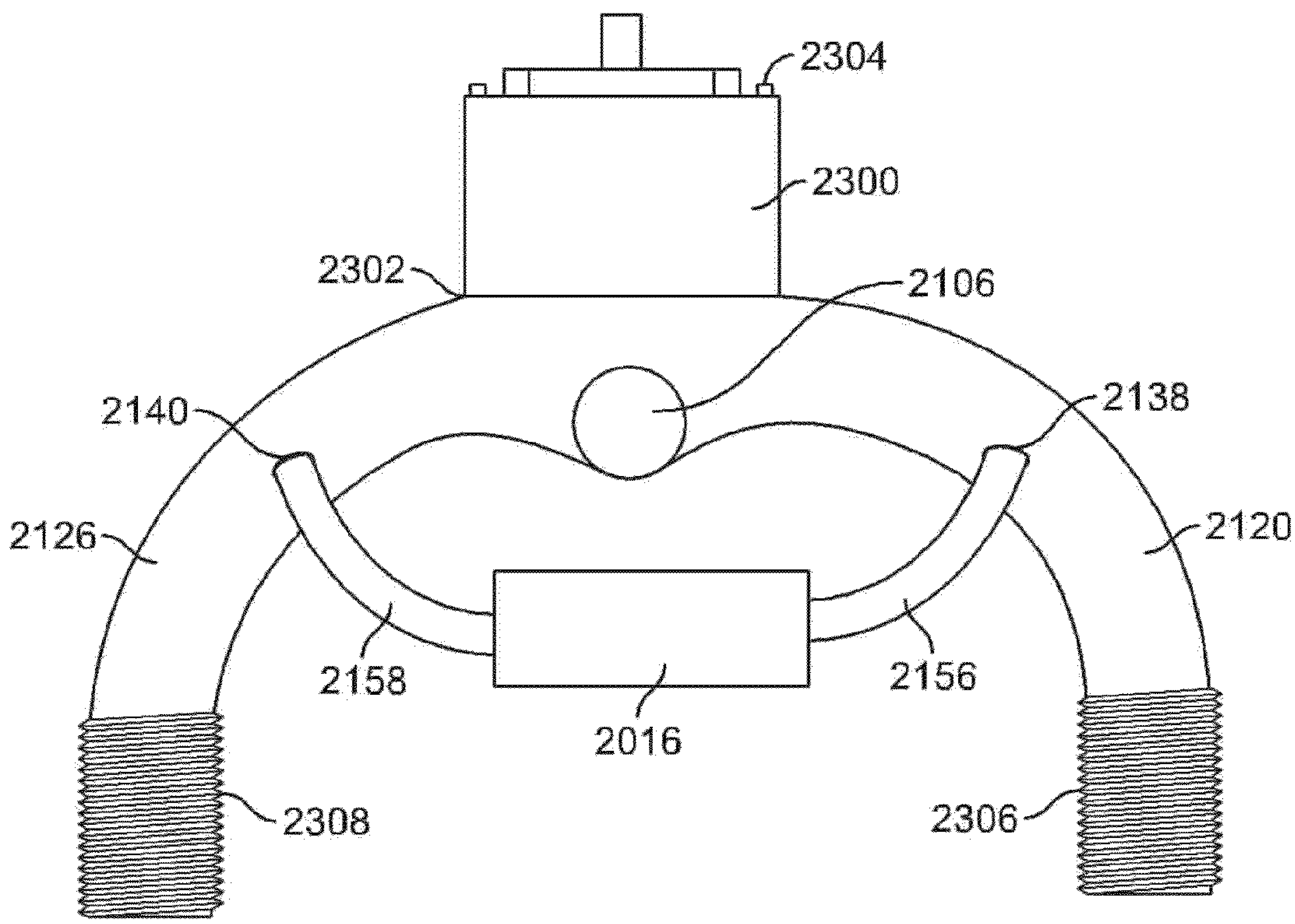
2304
2300
2302
2106
2140
2138
2126
2120
2158
2156
2016
2308
2306

FIG. 61

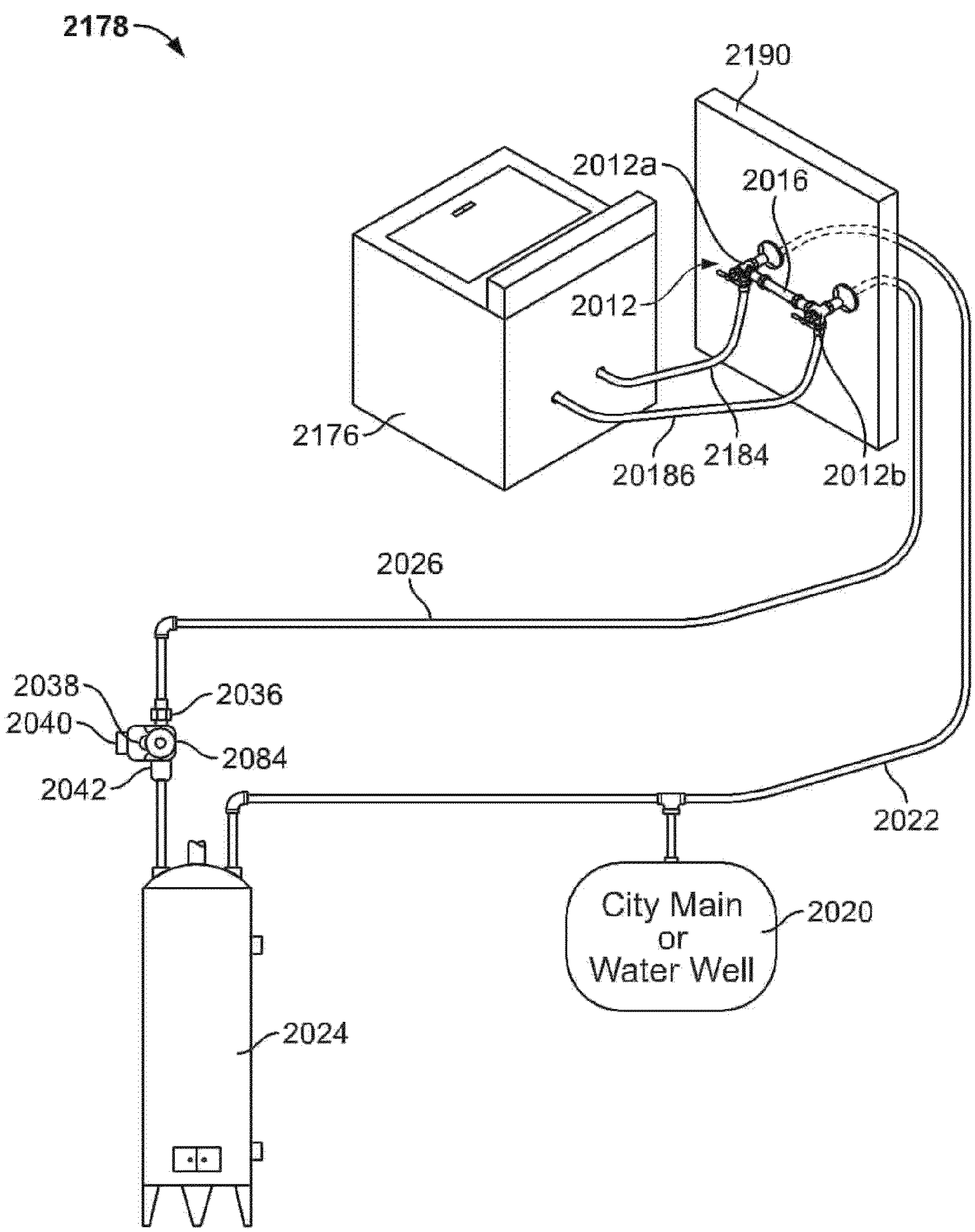
2178
2190
2012a
2016
2012
2176
20186
2184
2012b
2026
2038
2036
2040
2084
2042
2022
City Main
or
Water Well
2020
2024

FIG. 62

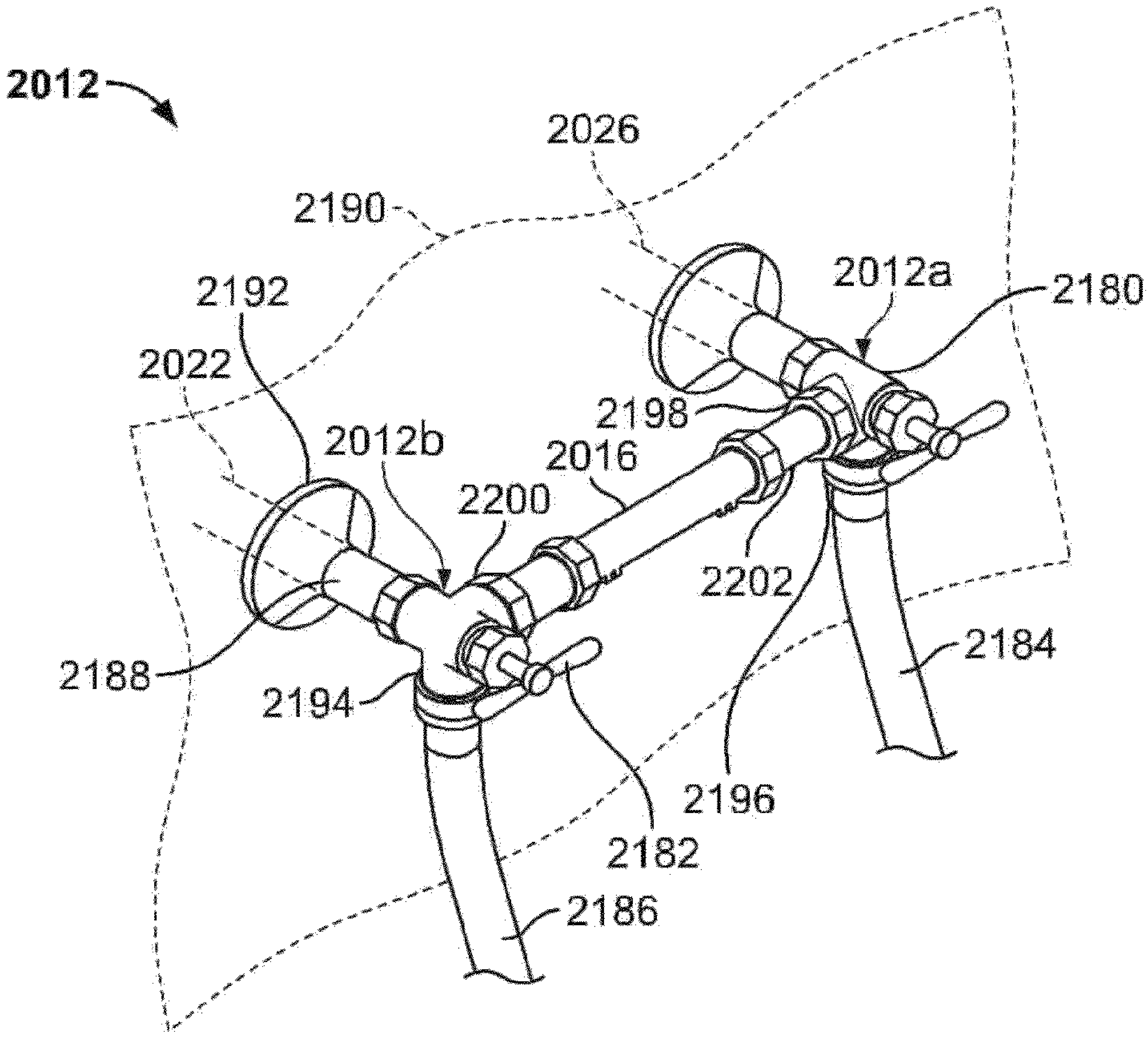
2012
2026
2190
2012a
2180
2192
2022
2198
2012b
2016
2200
2202
2184
2188
2194
2196
2182
2186

FIG. 63

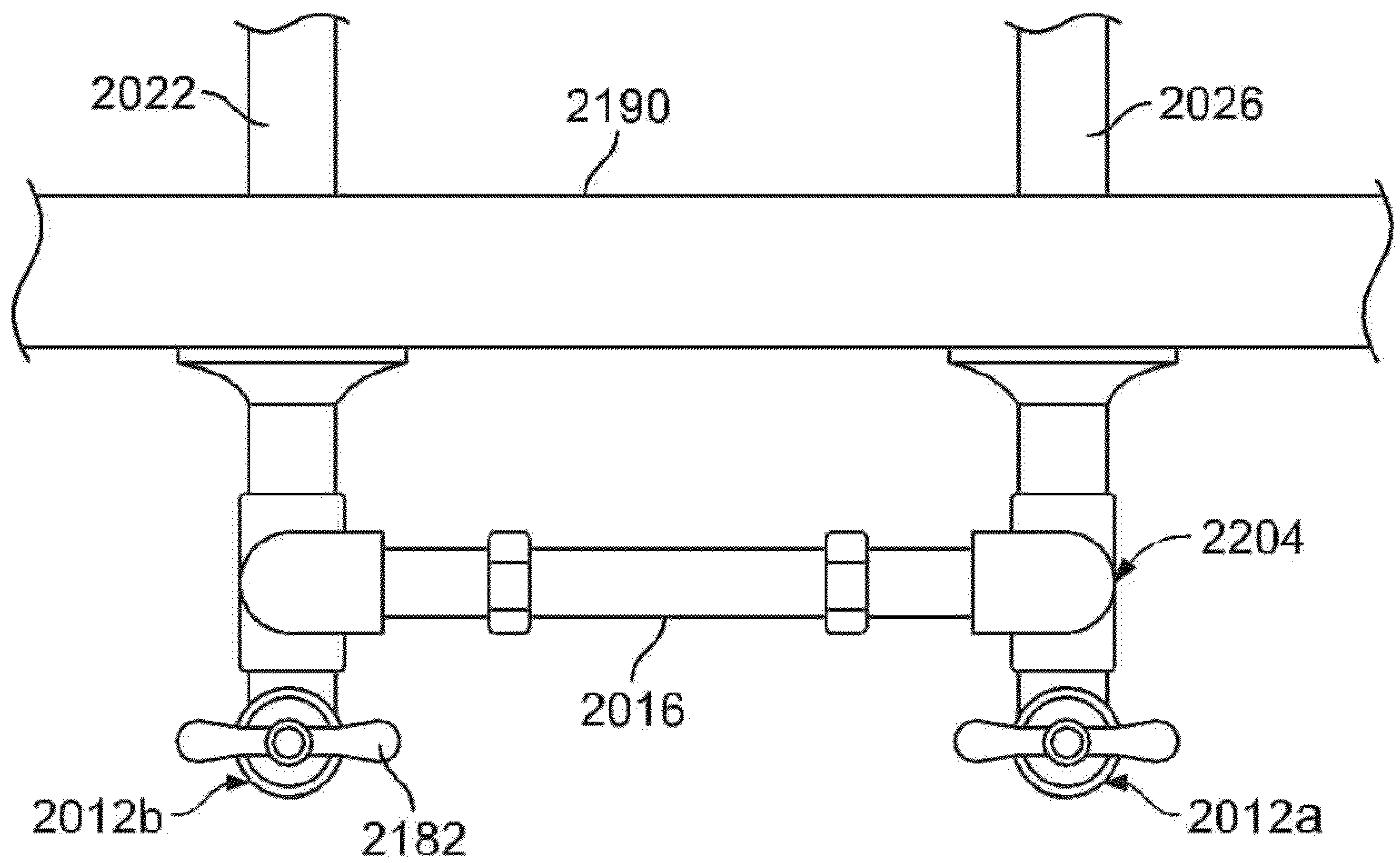
2022
2190
2026
2204
2016
2012b
2182
2012a

FIG. 64

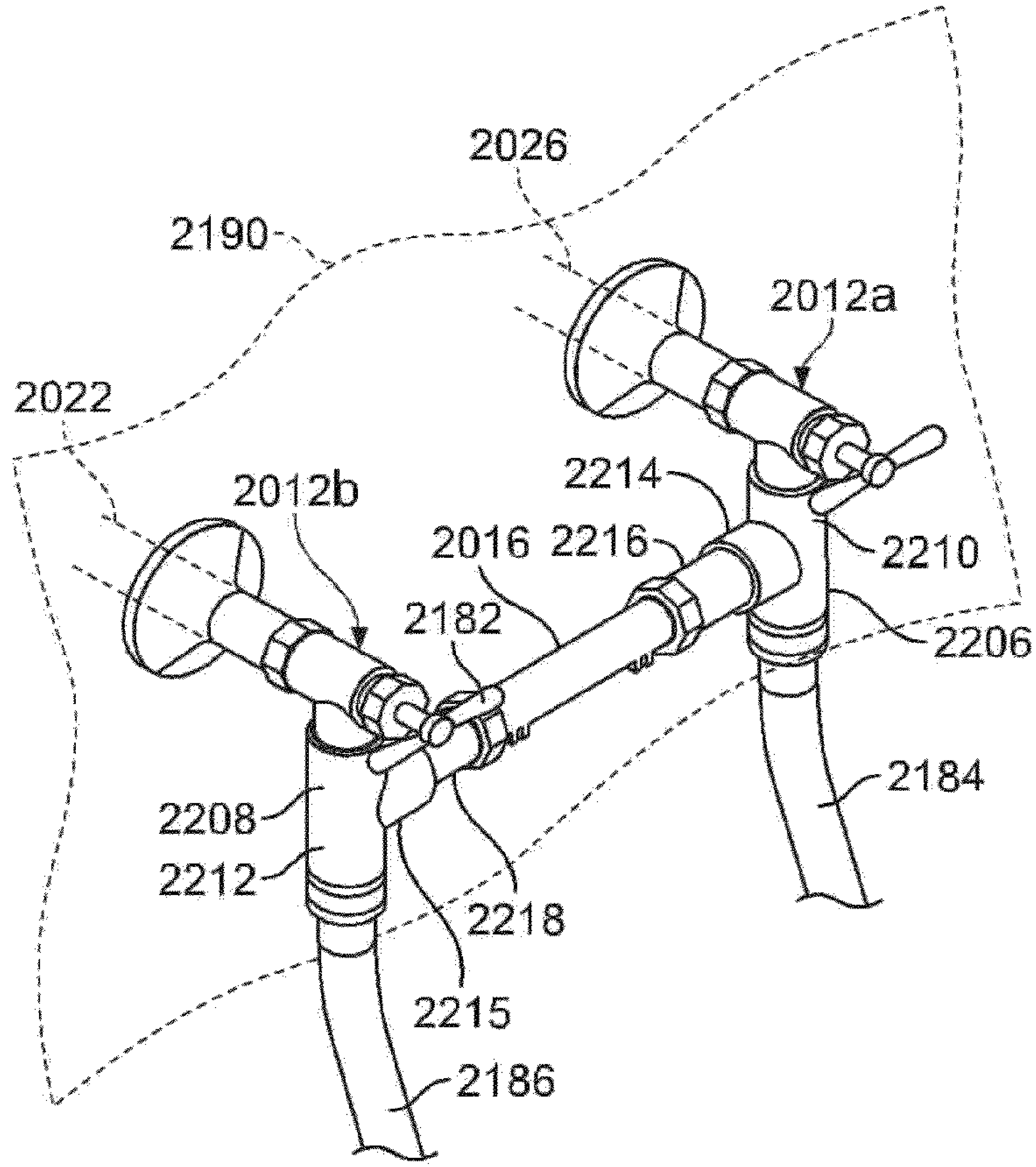
2026
2190
2012a
2022
2012b
2214
2016
2216
2210
2182
2206
2184
2208
2212
2218
2215
2186

FIG. 65

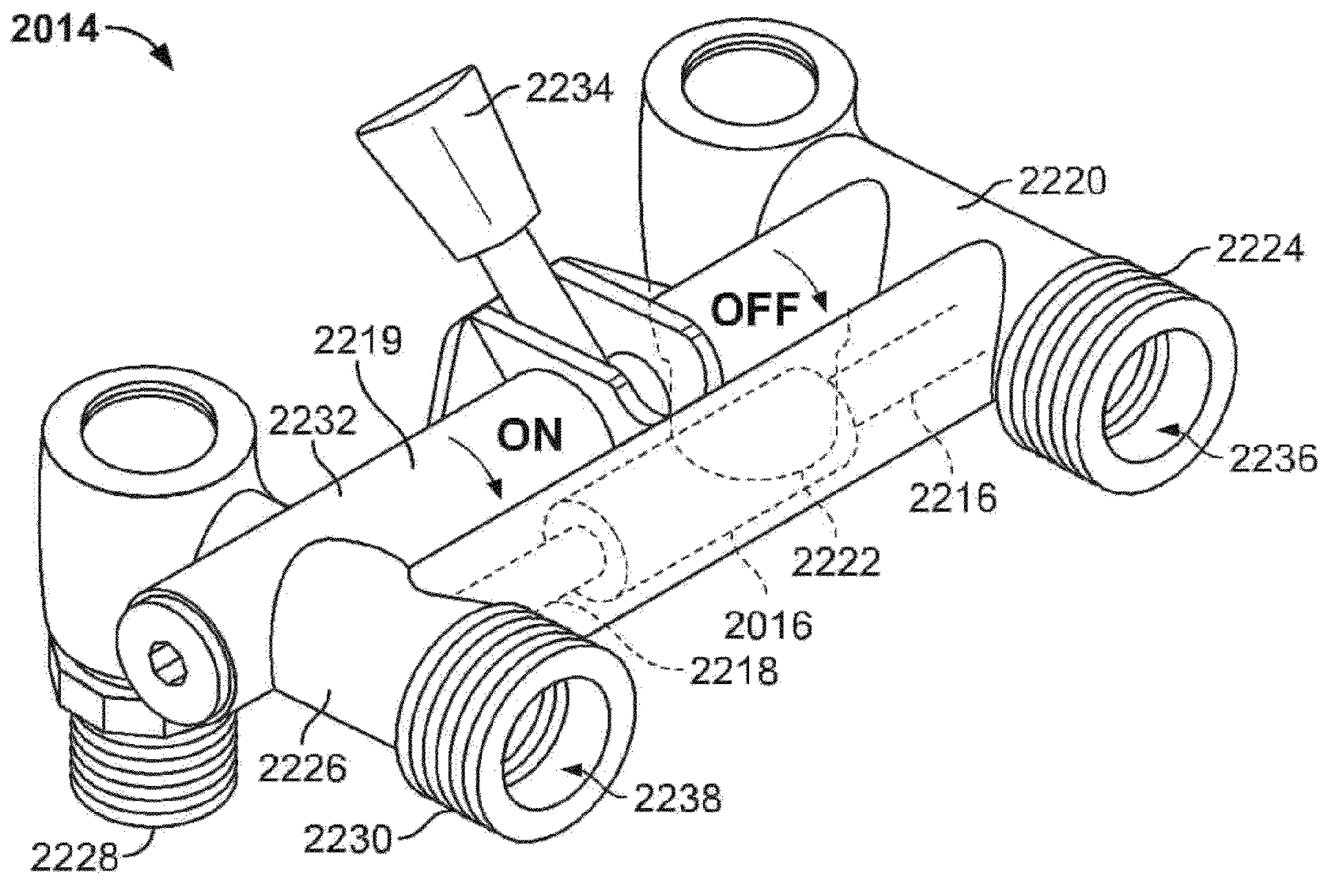
2014
2234
2220
2224
OFF
2219
2232
ON
2236
2216
2222
2016
2218
2226
2238
2230
2228

FIG. 66

WATER CONTROL VALVE ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 11/702,743, filed Feb. 5, 2007, which claims the benefit of and is a continuation of U.S. application Ser. No. 10/832,492, filed Apr. 27, 2004, now patented as U.S. Pat. No. 7,198,059, which claims the benefit of U.S. Provisional Application No. 60/465,854 filed Apr. 28, 2003; and which is a continuation-in-part of U.S. Patent application Ser. No. 10/394,795 filed Mar. 21, 2003, now patented as U.S. Pat. No. 7,073,528, which is a continuation-in-part of 10/006,970 filed Dec. 4, 2001, now patented as U.S. Pat. No. 6,929,187, which is a continuation-in-part of U.S. Patent application Ser. No. 09/697,520 filed Oct. 25, 2000, now patented as U.S. Pat. No. 6,536,464, which are each expressly incorporated herein by this reference.

BACKGROUND OF THE INVENTION

Certain embodiments relate generally to bypass valves for use in home or industrial water distribution systems that supply water to various fixtures at different temperatures through different pipes. More particularly, certain embodiments relate to such bypass valves that are thermostatically controlled so as to automatically bypass water that is not at the desired temperature for use at the fixture. Even more particular, certain embodiments relate to use of such a thermostatically controlled bypass valve in a water distribution system utilizing a single circulating pump at the water heater.

Certain embodiments relate generally to faucets and bypass valves for use in home or industrial water distribution systems that supply water to various fixtures at different temperatures through different pipes. More particularly, certain embodiments relate to faucets having bypass valves that are thermostatically controlled so as to automatically bypass water that is not at the desired temperature for use at the fixture. Even more particular, certain embodiments relate to faucets having an integral thermostatically controlled bypass valve.

Certain embodiments relate generally to water control valves for use in home or industrial water distribution systems that supply water to various fixtures at different temperatures through different pipe systems. More specifically, certain embodiments relate to such water control valves that are adaptable for use with a bypass valve so as to bypass cold or tepid water away from the associated fixture until it reaches the desired temperature. Certain embodiments are particularly useful for providing a water control valve having a bypass valve which is accessible through the support wall associated with the fixture and which can also be used with non-working or service valves.

Certain embodiments relate generally to apparatuses and systems for retrofitting water control valves used in home or industrial water distribution systems that supply water to various fixtures at different temperatures through different pipe systems. More specifically, certain embodiments relate to apparatuses and systems for retrofitting such water control valves to incorporate a bypass valve or other operating improvements, such as pressure balancing, without requiring removal or replacement of the valve housing that is mounted in the water distribution system. Even more specifically, certain embodiments relate to apparatuses and systems for retrofitting a tub/shower water control valve to incorporate a bypass valve so as to bypass cold or tepid water away from the associated fixture until it reaches the desired temperature.

Home and industrial water distribution systems distribute water to various fixtures, including sinks, bathtubs, showers, dishwashers and washing machines, that are located throughout the house or industrial building. The typical water distribution system brings water in from an external source, such as a city main water line or a private water well, to the internal water distribution piping system. The water from the external source is typically either at a cold or cool temperature. One segment of the piping system takes this incoming cold water and distributes it to the various cold water connections located at the fixtures where it will be used (i.e., the cold water side of a tub/shower valve). Another segment of the piping system delivers the incoming cold water to a water heater which heats the water to the desired temperature and distributes it to the various hot water connections where it will be used (i.e., the hot water side of the tub/shower valve). At the fixture, cold and hot water either flows through separate hot and cold water control valves that are independently operated to control the temperature of the water into the fixture by controlling the flow rate of water from the separate valves or, as is more typical for tub/shower installations, the water is mixed at a single valve that selectively controls the desired water temperature flowing from the fixture.

A well-known problem with most home and industrial water distribution systems is that hot water is not always readily available at the hot water side of the fixture when it is desired. This problem is particularly acute in water use fixtures that are located a distance from the hot water heater or in systems with poorly insulated pipes. When the hot water side of these fixtures is left closed for some time, such as overnight, the hot water in the hot water segment of the piping system sits in the pipes and cools. As a result, the temperature of the water between the hot water heater and the fixture lowers until it becomes cold or at least tepid. When opened again, it is not at all uncommon for the hot water side of such a fixture to supply cold water through the hot water valve when it is first opened and for some time thereafter. For instance, at the bathtub and/or shower fixture located some distance away from the water heater, the person desiring to use the tub/shower will either have to initially use cold or tepid water instead of hot water or wait for the distribution system to supply hot water through the open hot water valve. Most users have learned that to obtain the desired hot water, the hot water valve must be opened and left open for some time so that the cool water in the hot water side of the piping system will flow out ahead of the more recently heated hot water. For certain fixtures, such as virtually all dishwashers and washing machines, there typically is no easy method of "draining" away the cold or tepid water in the hot water pipes prior to utilizing the water in the fixture.

The inability to have hot water at the hot water side of the fixture when it is desired creates a number of problems. One problem, as described above, is having to utilize cold or tepid water when hot water is desired. Even in those fixtures where the person can allow the cold or tepid water to flow out of the fixture until the water reaches the desired warm or hot temperature, such as a bath or shower, there are certain problems associated with such a solution. One such problem is the waste of water that flows out of the fixture through the drain and, typically, to the sewage system. This good and clean water is wasted, resulting in unnecessary water treatment after flowing through the sewage system. This waste of water is compounded when the person is inattentive and hot water begins flowing down the drain and to the sewage system. Yet another problem associated with the inability to have hot water at the hot water valve when needed is the waste of time for the person who must wait for the water to reach the desired temperature before he or she-can take a bath or shower at the desired temperature.

The use of bypass valves and/or water recirculation systems in home or industrial water distribution systems to overcome the problems described above have been known for some time. The general objective of the bypass valve or recirculation system is to avoid supplying cold or tepid water at the hot water side of the piping system when the user desires hot water. U.S. Pat. No. 2,842,155 to Peters describes a thermostatically controlled water bypass valve, shown as FIG. **2** therein, that connects at or near the fixture located away from the water heater. The inventor discusses the problems of cool "hot" water and describes a number of prior art attempts to solve the problem. The bypass valve in the Peters patent comprises a cylindrical housing having threaded ends that connect to the hot and cold water piping at the fixture so as to interconnect these piping segments. Inside the housing at the hot water side is a temperature responsive element having a valve ball at one end that can sealably abut a valve seat. The temperature responsive element is a metallic bellows that extends when it is heated to close the valve ball against the valve seat and contracts when cooled to allow water to flow from the hot side to the cold side of the piping system when both the hot and cold water valves are closed. Inside the housing at the cold water side is a dual action check valve that prevents cold water from flowing to the hot water side of the piping system when the hot water valve or the cold water valve is open. An alternative embodiment of the Peters' invention shows the use of a spiral temperature responsive element having a finger portion that moves left or right to close or open the valve between the hot and cold water piping segments. Although the invention described in the Peters' patent relies on gravity or convection flow, similar systems utilizing pumps to cause a positive circulation are increasingly known. These pumps are typically placed in the hot water line in close proximity to the fixture where "instant" hot water is desired.

U.S. Pat. No. 5,623,990 to Pirkle describes a temperature-controlled water delivery system for use with showers and eye-wash apparatuses that utilize a pair of temperature responsive valves, shown as FIGS. **2** and **5** therein. These valves utilize thermally responsive wax actuators that push valve elements against springs to open or close the valves to allow fluid of certain temperatures to pass. U.S. Pat. No. 5,209,401 to Fiedrich describes a diverting valve for hydronic heating systems, best shown in FIGS. **3** through **5**, that is used in conjunction with a thermostatic control head having a sensor bulb to detect the temperature of the supply water, U.S. Pat. No. 5,119,988 also to Fiedrich describes a three-way modulating diverting valve, shown as FIG. **6**. A non-electric, thermostatic, automatic controller provides the force for the modulation of the valve stem against the spring. U.S. Pat. No. 5,287,570 to Peterson et al. discloses the use of a bypass valve located below a sink to divert cold water from the hot water faucet to the sewer or a water reservoir. As discussed with regard to FIG. **5**, the bypass valve is used in conjunction with a separate temperature sensor.

Recirculating systems for domestic and industrial hot water heating utilizing a bypass valve are disclosed in U.S. Pat. No. 5,572,985 to Benham and U.S. Pat. No. 5,323,803 to Blumenauer. The Benham system utilizes a circulating pump in the return line to the water heater and a temperature responsive or thermostatically actuated bypass valve disposed between the circulating pump and the hot water heater to maintain a return flow at a temperature level below that at the outlet from the water heater. The bypass valve, shown in FIG. **2**, utilizes a thermostatic actuator that extends or retracts its stem portion, having a valve member at its end, to seat or unseat the valve. When the fluid temperature reaches the desired level, the valve is unseated so that fluid that normally circulates through the return line of the system is bypassed through the circulating pump. The Blumenauer system utilizes an instantaneous hot water device comprising a gate valve and ball valve in a bypass line interconnecting the hot and cold water input lines with a pump and timer placed in the hot water line near the hot water heater.

Despite the devices and systems set forth above, many people still have problems with obtaining hot water at the hot water side of fixtures, particularly bath and/or shower fixtures, located away from the hot water heater or other source of hot water. Boosted, thermally actuated valve systems having valves that are directly operated by a thermal actuator (such as a wax filled cartridge) tend not to have any toggle action. Instead, after a few on-off cycles, the valves tend to just throttle the flow until the water reaches an equilibrium temperature, at which time the valve stays slightly cracked open. While this meets the primary function of keeping the water at a remote fixture hot, leaving the valve in a slightly open condition does present two problems. First, the lack of toggle action can result in scale being more likely to build up on the actuator because it is constantly extended. Second, the open valve constantly bleeds a small amount of hot or almost hot water into the cold water piping, thereby keeping the faucet end of the cold water pipe substantially warm. If truly cold water is desired (i.e., for brushing teeth, drinking, or making cold beverages), then some water must be wasted from the cold water faucet to drain out the warm water. If the bypass valve is equipped with a spring-loaded check valve to prevent siphoning of cold water into the hot water side when only the hot water faucet is open, then the very small flow allowed through the throttled-down valve may cause chattering of the spring loaded check valve. The chattering can be avoided by using a free floating or non-spring loaded check valve. It is also detrimental to have any noticeable crossover flow (siphoning) from hot to cold or cold to hot with any combination of faucet positions, water temperatures, or pump operation.

Related U.S. Pat. No. 6,536,464 describes an under-the-sink thermostatically controlled bypass valve and water circulating system with the bypass valve placed at or near a fixture (i.e., under the sink) to automatically bypass cold or tepid water away from the hot water side of the fixture until the temperature of the water reaches the desired level. Related U.S. Pat. No. 6,929,187 describes a water control fixture having a thermostatically controlled bypass valve integral with the fixture, either in a separate chamber or in the operating valve, for bypassing cold or tepid water away from the hot side of the fixture. Related U.S. Pat. No. 7,073,528 describes a bath and/or shower water control valve that is adapted to either attach to or which includes a bypass valve. Related patent application Ser. No. 10/832,492 describes apparatuses and systems for retrofitting an existing water control valve mounted in a water distribution system. Preferably, the above-mentioned bypass valves utilize a thermal actuator element that is thermally responsive to the temperature of the water to automatically control the diversion of water from the fixture, so as to maintain hot water availability at the hot water side of the fixture. The above described related patents and patent application address some of the aforementioned problems, however problems remain with known hot water recirculation systems.

SUMMARY OF THE INVENTION

In one aspect, a water control valve assembly is provided including a valve manifold having a mixing chamber for mixing water from a supply of hot water and a supply of cold water. The valve manifold has a water control element controlling the flow of water from the mixing chamber to a discharge port of the valve manifold. A thermostatically controlled bypass valve is in fluid communication with the valve manifold, wherein the bypass valve is configured to bypass water from the supply of hot water to the supply of cold water.

In another aspect, a water control valve assembly is provided including a valve manifold configured to be located proximate a fixture, wherein the valve manifold has a water control element controlling a flow of water to a discharge port of the valve manifold, and wherein the discharge port is configured to be in fluid communication with the fixture. A thermostatically controlled bypass valve is in fluid communication with the valve manifold, wherein the bypass valve is configured to bypass water from a supply of hot water to a supply of cold water.

In a further aspect, a water control valve assembly is provided including a valve manifold having a hot water inlet and a discharge port, wherein the hot water inlet is configured for connection to a supply of hot water and the discharge port configured to be in fluid communication with a fixture. The valve manifold further includes a water control element for controlling the flow of water through the discharge port. A thermostatically controlled bypass valve is in fluid communication with the valve manifold, wherein the bypass valve is configured to bypass water from the supply of hot water to a supply of cold water.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a water distribution system having a pump added to the hot water line to distribute hot and cold water to a water control valve in a shower/tub assembly.

FIG. **2** is a cross-sectional side view of a bypass valve for use with the water control valves.

FIG. **3** is a cross-sectional side view of the valve body of the bypass valve shown in FIG. **2**.

FIG. **4** is a side view of an exemplary thermally sensitive actuating element, shown in its unmodified condition, for use in an exemplary thermostatically controlled bypass valve.

FIG. **5** is a front view of a prior art shower/tub water control valve showing a valve cartridge disposed in the valve manifold of the water control valve.

FIG. **6** is a front view of the prior art shower/tub water control valve of FIG. **5** showing the valve cartridge removed from the valve manifold to expose the valve cartridge interface of the water control valve.

FIG. **7** is a front view of the first end of an adapter plug configured according to one embodiment showing a configuration for the first plug interface.

FIG. **8** is a side view of the adapter plug shown in FIG. **7**.

FIG. **9** is a front view of the second end of the adapter plug shown in FIG. **7** showing a configuration for the second plug interface.

FIG. **10** is cross-sectional side view of a retrofit system with an escutcheon plate having a blister portion covering the exposed end of the adapter plug and the retrofit valve.

FIG. **11** is a side view of a retrofit valve configured according to one embodiment showing the valve ports and stem of the retrofit valve.

FIG. **12** is a cross-sectional side view of the retrofit valve shown in FIG. **11** showing the use of both a water control cartridge having a pressure balance function and a bypass valve.

FIG. **13** is a side view of a prior art water control cartridge having a pressure balance function.

FIG. **14** is a side view of a prior art valve manifold.

FIG. **15** is a side view of an adapter plug configured according to one embodiment for the prior art valve manifold shown in FIG. **14**.

FIG. **16** is a cross-sectional side view of the adapter plug of FIG. **15**.

FIG. **17** is a side view one embodiment of a retrofit valve and fluid connectors shown with the adapter plug of FIG. **15** installed in the prior art manifold of FIG. **14**.

FIG. **18** is a side view of one configuration of a bracket shown attached to the valve manifold of a water control valve.

FIG. **19** is a side view of a second configuration of a bracket shown attached to the valve manifold of a water control valve.

FIG. **20** is a front view of the bracket shown in FIG. **19**.

FIG. **21** is a top view of the second bracket member of the bracket shown in FIG. **20**.

FIG. **22** is a chart showing the operational characteristics of the thermostatically controlled bypass valve when in use with a water distribution system.

FIG. **23** is a side cross-sectional view of a modified thermal actuator showing modifications to reduce potential problems with lime buildup.

FIG. **24** is a perspective view of an assembled thermostatically controlled bypass valve formed in accordance with an embodiment.

FIG. **25** is a cross-sectional side view of the bypass valve in FIG. **24**.

FIG. **26** is a cross-sectional side view of the valve body of the bypass valve of FIG. **24**.

FIG. **27** is an end view of the second end of the valve body of the bypass valve of FIG. **24**.

FIG. **28** is an end view of the first end of the valve body of the bypass valve of FIG. **24**.

FIG. **29** is a side view of the thermally sensitive actuating element for use in the bypass valve of FIG. **24**.

FIG. **30** is a side elevation view showing a water distribution system and fixture utilizing the bypass valve of FIG. **24**.

FIG. **31** shows an exemplary water distribution system that utilizes a water control fixture (faucet) having a thermostatically controlled bypass valve.

FIG. **32** is a side view of an exemplary thermally sensitive actuating element, shown in its unmodified condition, for use in the bypass valve shown in FIG. **31**.

FIG. **33** is a front view of a typical fixture body for a single handle faucet.

FIG. **34** is a side view of the single handle faucet in FIG. **33**.

FIG. **35** is a top view of the faucet body housing for the faucet of FIG. **33**.

FIG. **36** is a side cross-sectional view of the faucet body housing for the faucet of FIG. **33**.

FIG. **37** is a bottom view of the faucet body housing of the faucet of FIG. **33**.

FIG. **38** is a sectional view of a bypass valve cartridge body for use with the bypass valve of FIG. **31**.

FIG. **39** is a sectional view of the bypass valve cartridge body taken at 90 degrees to FIG. **38**.

FIG. **40** is a sectional view of the bypass valve cartridge body of FIG. **38** with a bypass valve and other components place therein.

FIG. **41** is a cross-sectional view of the side of an exemplary shower faucet that utilizes a cartridge insert (not shown) for controlling the flow of water through the faucet showing the placement of a bypass valve therein.

FIG. **42** is a cross-sectional view of the side of an exemplary modified ball control mechanism for use in single handle faucets.

FIG. **43** is a top view of the ball of FIG. **42**.

FIG. **44** is a side view of the ball of FIG. **42**.

FIG. **45** is a cross sectional view of an exemplary modified replaceable cylindrical valving cartridge used in some faucets.

FIG. **46** is a side view of an exemplary valve member used with dual handle, single spout faucets.

FIG. **47** is side cross-sectional view of the upper half of a cartridge placed in the valve member of FIG. **46**.

FIG. **48** shows another exemplary water distribution system utilizing a water control valve having a bypass valve in a shower/tub assembly.

FIG. **49** is a cross-sectional side view of an exemplary bypass valve for use with the water control valves.

FIG. **50** is a cross-sectional side view of the valve body of the bypass valve shown in FIG. **49**.

FIGS. **51** and **51**A are side views of exemplary thermally sensitive actuating elements, shown in unmodified conditions, for use in the thermostatically controlled bypass valve shown in FIG. **49**.

FIG. **52** is a front view of the shower/tub water control valve without the bypass valve mounted thereon as seen through the opening in the support wall for a shower system.

FIG. **53** is a side view of the water control valve of FIG. **52** showing the interior components of a bypass valve mounted thereon.

FIG. **54** is a front view of a shower/tub water control valve having a bypass valve assembly mounted thereon.

FIG. **55** is a side view of the shower/tub water control valve of FIG. **54** without the bypass assembly mounted thereon showing the hot and cold water bypass ports for connection to the bypass valve.

FIG. **56** is a cross-sectional side view of an exemplary modified bypass valve for use with the water control valves.

FIG. **57** is a front view of a shower/tub water control valve having a bypass valve attached to the water control valve and tubular lines interconnecting the bypass ports on the water control valve and the bypass valve.

FIG. **58** is a front view of a shower/tub water control valve connected to a pair of bypass connectors that connect to a bypass valve attached to the water control valve.

FIG. **59** is a front view of a shower/tub water control valve having a bypass valve adjacent to the water control valve and connected to bypass ports on the water control valve.

FIG. **60** is a front view of a shower/tub water control valve connected to a pair of bypass connectors that connect to a bypass valve positioned adjacent to the water control valve.

FIG. **61** is a front view of a tub water control valve having an alternative configuration for the valve manifold with the bypass valve adjacent to the water control valve and connected to bypass ports on the water control valve.

FIG. **62** is another alternative water distribution system utilizing an exemplary water control valve as a service valve for a water utilizing apparatus.

FIG. **63** is a perspective view of a pair of water control valves modified for use with an interconnecting bypass valve.

FIG. **64** is a top view of a pair of water control valves utilizing a pair of saddle valves to interconnect with a bypass valve.

FIG. **65** is a perspective view of a pair of water control valves utilizing a pair of bypass connectors to interconnect with a bypass valve.

FIG. **66** is perspective view of a combination water control valve utilizing a bypass valve therein to interconnect the hot and cold components of the water control valve.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to the figures where like elements have been given like numerical designations to facilitate the reader's understanding, preferred embodiments are set forth below. The enclosed figures and drawings are illustrative of the preferred embodiments and represent preferred operations and orientations. Although specific components, materials, configurations and uses are illustrated, it should be understood that a number of variations to the components and to the configuration of those components described herein and in the accompanying figures can be made without changing the scope and function of the invention set forth herein.

In the accompanying drawings of the various preferred embodiments of a water control valve, the tub/shower water control valve is shown as **10** (i.e., FIGS. **1** and **5**) and a bypass valve is shown as **16** (i.e., FIG. **2**) that is adaptable for use with the apparatus and system for retrofitting water control valve **10**. However, other water control valves may be adaptable to the system for incorporating bypass valve **16**, as described herein. Bypass valve **16** for use with water control valve **10** can be one of many different types of available bypass valves, including a thermostatically controlled bypass valve (as described in the patent and co-pending patent applications referenced above), an electric solenoid controlled bypass valve, a needle-type bypass valve as described in the above-referenced Blumenauer patent or a mechanical push button bypass valve such as sold by Laing and others. Pursuant to various embodiments of the apparatus and system, as described in detail below, water control valve **10** is adaptable for use with various types of bypass valves **16**.

A typical water distribution system **18** utilizing tub/shower water control valve **10** is illustrated in FIG. **1**. A standard water distribution system **18** typically comprises a supply of cold water **20**, such as from a city main or water well, that supplies cold water directly to water control valve **10** through cold water line **22** and water to hot water heater **24** so that it may heat the water and supply hot water to water control valve **10** through hot water line **26**. Cold water line **22** connects to water control valve **10** at cold water inlet **28** and hot water line **26** connects to water control valve **10** at hot water inlet **30**, as explained in more detail below. The preferred water distribution system **18** utilizes a small circulating pump **32** of the type used in residential hot water space heating. A very low flow and low head pump **32** is desirable because a larger (i.e., higher head/higher flow) pump mounted at the typical domestic water heater **24** tends to be noisy. This annoying noise is often transmitted by the water pipes throughout the house, In addition, if the tub/shower system **34** (as an example) is already in use when pump **32** turns on, whether the first start or a later cyclic turn-on, the sudden pressure boost in the hot water line **26** from a larger pump can result in an uncomfortable and possibly near-scalding temperature rise in the water at the shower head or other fixture in use. The smaller boost of a "small" pump (i.e., one with a very steep flow-head curve) will result in only a very small and less noticeable increase in shower temperature.

In an embodiment, the single, small pump **32** needs to provide only a flow of approximately 0.3 gpm at 1.0 psi pressure. In accordance with pump affinity laws, such a "small" pump requires a very small impeller or low shaft speed. The inventors have found that use of a very small impeller or low shaft speed also precludes formation of an air bubble in the eye of the impeller, which bubble may be a major cause of noise. Such a small steep curve pump may, however, constitute a significant pressure drop in the hot water line **26** when several fixture taps are opened simultaneously (such as a bathtub and the kitchen sink). To avoid reduced flow in those installations having a relatively low volume pump, a check valve **36** can be plumbed in parallel with pump **32** or incorporated within the pump housing, to pass a flow rate exceeding the pump's capacity around pump **32**. When pump **32** is powered and flow demand is low, check valve **36** prevents the boosted flow from re-circulating back to its own inlet. With check valve **36** plumbed around pump **32**, it is advantageous to place an orifice **38** in the pump discharge to provide a simple manner to achieve the desired very steep flow-head curve from available stock pump designs. A single pump **32** located at or near water heater **24** in its discharge piping will boost the pressure in the hot water pipes somewhat above that in the cold water pipes (i.e., perhaps one to three feet of boost). With this arrangement only one pump **32** per plumbing system (i.e., per water heater **24**) is required with any reasonable number, such as the typical number used in residences, of remote water control valves (i.e., tub/shower valve **10**), equipped with bypass valve **16** by retrofitting according to embodiments of the apparatus and system. This is in contrast to those systems that require multiple pumps **32**, such as a pump **32** at each fixture where bypassing is desired.

If desired, pump **32** can operate twenty-four hours a day, with most of the time in the no flow mode. However, this is unnecessary and wasteful of electricity. Alternatively, and preferably, pump **32** can have a timer **40** to turn pump **32** on daily at one or more times during the day just before those times when hot water is usually needed the most (for instance for morning showers, evening cooking, etc.) and be set to operate continuously for the period during which hot water is usually desired. This still could be unnecessary and wasteful of electricity. Another alternative is to have the timer **40** cycle pump **32** on and off regularly during the period when hot water is in most demand. The "on" cycles should be of sufficient duration to bring hot water to all remote fixtures that have water control valves (such as tub/shower valve **10**) equipped with bypass valve **16**, and the "off" period would be set to approximate the usual time it takes the water in the lines to cool-down to minimum acceptable temperature. Yet another alternative is to equip pump **32** with a normally closed flow switch **42** sized to detect significant flows only (i.e., those flows that are much larger than the bypass flows), such as water flow during use of shower system **34**. For safety purposes, the use of such flow switch **42** is basically required if a cyclic timer **40** is used. The switch **42** can be wired in series with the motor in pump **32**. If switch **42** indicates an existing flow at the moment timer **40** calls for pump **32** to be activated, open flow switch **42** will prevent the motor from starting, thereby avoiding a sudden increase in water temperature at tub/shower fixture **34** being utilized. The use of switch **42** accomplishes several useful objectives, including reducing electrical power usage and extending pump **32** life if hot water is already flowing and there is no need for pump **32** to operate, avoiding a sudden temperature rise and the likelihood of scalding that could result from the pump boost if water is being drawn from a "mixing" valve (such as tub/shower valve **10** shown in FIG. **1** or a single handle faucet) and allowing use of a "large" pump **32** (now that the danger of scalding is eliminated) with its desirable low pressure drop at high flows, thereby eliminating the need for the parallel check valve **36** required with a "small" pump **32**.

By using a time-of-day control timer **40**, pump **32** operates to maintain "instant hot water" only during periods of the day when it is commonly desired. During the off-cycle times, the plumbing system **18** operates just as if the fixture having bypass valve **16** and pump **32** were not in place. This saves electrical power usage from operation of pump **32** and, more importantly, avoids the periodic introduction of hot water into relatively uninsulated pipes during the off-hours, thereby saving the cost of repeatedly reheating this water. The time-of-day control also avoids considerable wear and tear on pump **32** and bypass valve **16**. Considerable additional benefits are gained by using a cyclic timer **40**, with or without the time-of-day control. In addition to saving more electricity, if a leaky bypass valve **16** (i.e., leaks hot water to cold water line **22**) or one not having toggle action is used, there will be no circulating leakage while the pump **32** is cycled off, even if bypass valve **16** fails to shut off completely. Therefore, a simple (i.e., not necessarily leak tight) bypass valve **16** may suffice in less demanding applications. Reducing leakage to intermittent leakage results in reduced warming of the water in cold water line **22** and less reheating of "leaking" re-circulated water.

As described above, various types of bypass valves **16** may be utilized to accomplish the objective of bypassing cold or tepid water around the tub/shower fixture **34** associated with water control valve **10**, which is adaptable for use with bypass valve **16**. The preferred bypass valve **16** is the thermostatically controlled type, an example of which is shown in FIG. **2** and described in detail below, due to its ability to automatically sense and respond to the temperature of the water in hot water line **26** at water control valve **10**. Unlike the electrical solenoid type of bypass valve or the manually operated type of bypass valve, a thermostatically controlled bypass valve **16** does not require any external operational input to activate in order to bypass cold or tepid water in hot water line **26** so as to maintain hot water at hot water inlet **30** of water control valve **10**.

As best shown in FIGS. **2** through **4**, the preferred thermostatically controlled bypass valve **16**, which can be configured for use with water control valve **10**, comprises a generally tubular bypass valve body **44** having bypass valve inlet **46**, bypass valve outlet **48** and a separating wall **50** disposed therebetween. As described in more detail below, bypass inlet **46** hydraulically connects to hot water inlet **30** and bypass outlet **48** hydraulically connects to cold water inlet **28** of water control valve **10**. Bypass valve passageway **52** in separating wall **50** interconnects inlet **46** and outlet **48** to allow fluid to flow therethrough when bypass valve **16** is bypassing cold or tepid water. As best shown in FIG. **2** and discussed in more detail below, valve body **44** houses a thermally sensitive actuating element **54**, bias spring **56**, an over-travel spring **58**, self-cleaning screen **60**, retaining mechanism **62** (such as a retaining ring, clip, pin or other like device) and check valve **64**. The direction of flow for check valve **64** is shown with the arrow in FIG. **2**. Valve body **44** can most economically and effectively be manufactured out of a molded plastic material, such as Ryton®, a polyphenylene sulphide resin available from Phillips Chemical, or a variety of other composites. In general, molded plastic materials are preferred due to their relatively high strength and chemical/corrosion resistant characteristics while providing the ability to manufacture the valve body **44** utilizing injection molding processes with the design based on the configuration described herein without the need for expensive casting or machining. Alternatively, valve body **44** can be manufactured from various plastics, reinforced plastics or metals that are resistant to hot chlorinated water under pressure. As shown in FIG. **3**, inlet **46** of valve body **44** can be molded with a set of axially oriented fin guides **66** having ends that form an internal shoulder **68** inside valve body **44** for fixedly receiving and positioning one end of thermal actuating element **54** and bias spring **56**, and retainer interruption **72** for receiving retaining mechanism **62**. Preferably, retaining mechanism **62** is a retaining ring and retainer interruption **72** is configured such that when retaining mechanism **62** is inserted into valve body **44** it will be engagedly received by retainer interruption **72**. Bypass valve outlet **48** can be molded with retaining slot **74** for engagement with the snap-in check valve **64**. In the preferred embodiment, valve body **44** is designed so the internal components can fit through inlet **46** and outlet **48**, which will typically be, nominally, one-half inch diameter. In this manner, a one piece bypass valve **16** results with no intermediate or additional joints required for installation. In the preferred embodiment, the end having bypass valve inlet **46** is kept close to screen **60** so that the full flow of hot water (when water is flowing from the tub spout or shower head) will wash across the surface of screen **60**, making it self-cleaning.

An example of a thermally sensitive actuating element **54** for use with the thermostatically controlled bypass valve **16** is shown in FIG. **4**. Actuating element **54** is preferably of the wax filled cartridge type, also referred to as wax motors, having an integral poppet rod member **76** comprising poppet **78** attached to piston **80** with an intermediate flange **82** thereon. The end of poppet **76** is configured to seat directly against valve seat **70** or move a shuttle (i.e., spool or sleeve valves) so as to close passage **52**. These thermostatic control actuating elements **54** are well known in the art and are commercially available from several suppliers, such as Caltherm of Bloomfield Hills, Mich. The body **84** of actuating element **54** has a section **86** of increased diameter, having a first side **88** and second side **90**, to seat against shoulder **68** or like element in valve body **44**. Piston **80** of rod member **76** interconnects poppet **78** with actuator body **84**. Actuating element **54** operates in a conventional and well known manner. Briefly, actuating element **54** comprises a blend of waxes or a mixture of wax(es) and metal powder (such as copper powder) enclosed in actuator body **84** by means of a membrane made of elastomer or the like. Upon heating the wax or wax with copper powder mixture expands, thereby pushing piston **80** and poppet **78** of rod member **76** in an outward direction. Upon cooling, the wax or wax/copper powder mixture contracts and rod member **76** is pushed inward by bias spring **56** until flange **82** contacts actuator body **54** at actuator seat **92**. Although other types of thermal actuators, such as bi-metallic springs and memory alloys (i.e., Nitinol and the like) can be utilized, the wax filled cartridge type is preferred because the wax can be formulated to change from the solids to the liquid state at a particular desired temperature. The rate of expansion with respect to temperature at this change of state is many times higher, resulting in almost snap action of the wax actuating element **54**. The temperature set point is equal to the preset value, such as 97 degrees Fahrenheit, desired for the hot water. This is a "sudden" large physical motion over a small temperature change. As stated above, this movement is reacted by bias spring **56** that returns rod member **76** as the temperature falls.

Because bypass valve **16** has little or no independent "toggle action," after a few consecutive cycles of opening and closing, bypass valve **16** tends to reach an equilibrium with the plumbing system, whereby bypass valve **16** stays slightly cracked open, passing just enough hot water to maintain the temperature constantly at its setting. In particular plumbing systems and at certain ambient conditions, this flow is just under that required to maintain a spring loaded check valve cracked continuously open (i.e., check valve **36**). In such a situation, check valve **36** chatters with an annoying buzzing sound. To avoid this occurrence, the spring may be removed from check valve **36**, leaving the check valve poppet free floating. In the event that the hot water is turned full on at a time when bypass valve **16** is open, thereby towering the pressure in hot water line **26** and inducing flow from cold water line **22** through the open bypass valve **16** to the hot side, the free floating poppet will quickly close. There is no necessity for a spring to keep check valve **36** closed prior to the reversal in pressures.

Although not entirely demonstrated in early tests, it is believed that beneficial "toggle" action can be achieved with an altered version of the thermostatically controlled bypass valve **16** discussed above. If the motion of actuating element **54** is made to lag behind the temperature change of the water surrounding it by placing suitable insulation around actuating element **54** or by partially isolating it from the "hot" water, then instead of slowly closing only to reach equilibrium at a low flow without reaching shutoff, the water temperature will rise above the extending temperature of the insulated actuating element **54** as bypass valve **16** approaches shutoff, and piston **80** will then continue to extend as the internal temperature of actuating element **54** catches up to its higher surrounding temperature, closing bypass valve **16** completely. It is also believed that an insulated actuating element **54** will be slow opening, its motion lagging behind the temperature of the surrounding cooling-off water from which it is insulated. When actuating element **54** finally allows bias spring **56** to open bypass valve **16** and allow flow, the resulting rising temperature of the surrounding water will again, due to the insulation, not immediately affect it, allowing bypass valve **16** to stay open longer for a complete cycle of temperature rise. Such an "insulated" effect may also be accomplished by use of a wax mix that is inherently slower, such as one with less powdered copper or other thermally conductive filler. An actuating element **54** so altered can be manufactured with a somewhat lower set point temperature to make up for the lag, achieving whatever bypass valve **16** closing temperature desired.

An additional benefit of utilizing pump **32** in a cyclic mode in system **18** is that shut-off of a toggle action valve upon attainment of the desired temperature is enhanced by the differential pressure an operating pump **32** provides. If pump **32** continues to run as the water at water control valve **10** cools down, the pump-produced differential pressure works against re-opening a poppet type bypass valve **16**. If pump **32** operates cyclically, powered only a little longer than necessary to get hot water to water control valve **10**, it will be "of? before the water at bypass valve **16** cools down. When the minimum temperature is reached, actuating element **54** will retract, allowing bias spring **56** to open bypass valve **16** without having to fight a pump-produced differential pressure. Bypass flow will begin with the next pump "on" cycle. An additional benefit to the use of either a time-of-day or cyclic timer **40** or the above mentioned insulated actuating element **54** is that it improves the operating life of actuating element **54**. Because use of either cyclic timer **40** or insulated element **54** causes cyclic temperature changes in bypass valve **16** (as opposed to maintaining an equilibrium setting wherein temperature is constant and actuating element **54** barely moves), there is frequent, substantial motion of the piston **80** in actuating element **54**. This exercising of actuating element **54** tends to prevent the build-up of hard water deposits and corrosion on the cylindrical surface of actuator piston **80** and end face of poppet **78**, which deposits could render bypass valve **16** inoperable.

Also inside bypass valve **16** can be an over-travel spring **58** disposed between the second side **90** of the actuator body **84** and a stop, such as retaining mechanism **62** shown in FIG. **2**, located inside bypass valve **16** to prevent damage to a fully restrained actuating element **54** if it were heated above the maximum operating temperature of bypass valve **16** and to hold actuating element **54** in place during operation without concern for normal tolerance. Use of over-travel spring **58**, which is not necessary for spool-type valves, allows movement of actuator body **84** away from the seated poppet **78** in the event that temperature rises substantially after poppet **78** contacts valve seat **70**. Without this relief, the expanding wax could distort its copper can, destroying the calibrated set point. Over-travel spring **58** also holds bias spring **56**, rod member **76** and actuator body **84** in place without the need to adjust for the stack-up of axial tolerances. Alternatively, actuating element **54** can be fixedly placed inside bypass valve **16** by various mechanisms known in the art, including adhesives and the like. Over-travel spring **58**, if used, can be held in place by various internal configurations commonly known in the art, such as a molded seat (not shown).

Although there are a great many manufacturers and configurations of water control valves **10**, it is believed that there are several generic forms of such valves that can be used. The water control valves **10** adaptable for use with bypass valve **16**, including but not limited to thermostatically controlled bypass valves, include various types of combination shower/tub valve **10**. As such, these generic forms of water control valve **10** are utilized below to illustrate several different types of designs that are adaptable for the use of bypass valve **16** therewith according to the apparatus and system for retrofitting water control valve **10**. The opportunity afforded by water control valve **10** is the access to the hot, cold and discharge ports when the existing valve cartridge is removed and replaced with an adapter plug, as discussed in detail below. The following examples are only representative of the types of water control valves **10** with which bypass valve **16** can be used. As is well known in the art, the individual manufacturers have various models of water control valves to incorporate desired features and preferences. The examples are for illustrative purposes only and are not intended to restrict the bypass valve **16** to particular uses, sizes or materials used in the examples.

As is well known, many homes have a combination shower and tub assembly whereby the same water control valve **10** is used to control the flow and temperature to the shower and the tub. A selector valve (not shown) is typically used to select the flow between the shower and the tub. An example shower/tub system is shown as **34** in FIG. **1**. A similar water control valve to that shown as **10**, is used for systems comprising only a shower or a tub, with the exception that such valve only has one discharge port (connected to either the shower or the tub). In the shower/tub system **34**, water control valve **10**, distributes water to shower head assembly **100** through shower line **102** and to tub spout **104** through tub line **106**, as exemplified in the system of FIG. **1**. A flow control handle **108** is used to control the flow and temperature of water to the shower head assembly **100** or tub spout **104**. Although a single flow control handle **108** is shown in FIG. **1**, it is understood that some shower, tub and shower/tub flow control valves utilize separate handles for the hot and cold water control. One of the primary distinguishing characteristics of virtually all existing shower/tub water control valves **10** is that they are positioned at least partially behind support wall **110** that forms part of the shower and/or tub enclosure and which is used to support shower head assembly **100** and tub spout **104**. Because access to water control valve **10** is important for maintenance or repair of water control valve **10**, even if positioned entirely behind support wall **110**, water control valve **10** is generally placed behind an opening **112** in support wall **110** specifically configured for accessing water control valve **10**. Typically a removable plate **114**, commonly referred to as an escutcheon plate, is used to cover opening **112**. To access water control valve **10**, plate **114** is removed and valve **10** is maintained or repaired through opening **112** in support wall **110** and then plate **114** is reinstalled.

A typical tub/shower water control valve **10**, such as the Peerless® valve shown in more detail in FIG. **5**, is used to illustrate various configurations that are adaptable for retrofit use with bypass valve **16**. The typical water control valve **10** comprises a valve manifold (body/housing) **118** having a hot water inlet **120** that connects to hot water line **26** to allow hot water to flow through control valve hot passageway **122** to the inner valve workings, which generally comprise a removable valve cartridge **123** disposed inside cartridge receptor **124** of valve manifold **118**, and a cold water inlet **126** that connects to cold water line **22** to allow cold water to flow through control valve cold passageway **128** to valve cartridge **123** inside cartridge receptor **124**. Typically, cartridge receptor **124** is configured as a cylindrical or spherical cavity that is sized to receive valve cartridge **123** therein. Alternatively, cartridge receptor **124** may be configured as a generally flat surface on which valve cartridge **123** is mounted or attached (such as utilized in the American Standard model 6211 water control valve). In either configuration, as well as others, cartridge receptor **124** has three ports, one each for the inflow of hot and cold water from hot water line **26** and cold water line **22**, respectively, and one for the discharge of mixed water to shower line **102** and/or tub line **106**. When joined to cartridge mounting surface, valve cartridge **123** controls the mix of hot and cold water to shower head assembly **100** or tub spout **104** through shower discharge **130** to shower line **102** or through tub discharge **132** to tub line **106**, respectively. Tub/shower water control valves **10** intended for installation behind support wall **110** adjacent to shower system **34** have been and are commonly permanently or at least somewhat permanently plumbed into the water distribution system **16** such that valve manifold **118** is not replaceable without tearing out a wall and physically removing the valve manifold **118** (i.e., by sawing) from water distribution system **18**. The dynamic seals and mating surfaces on the valving members that are subject to wear are generally internal to replaceable valve cartridge **123**. For the dual handle designs, having separate handles for the hot and cold water valves, the faucet washer on a rising stem could be replaced, as could the valve stem, bonnet packing and valve seat. On the more modern water control valves, such as that shown as **10** in FIG. **5**, the entire valve cartridge **123** is replaceable. Because all dynamic valving action is done internally in these modern cartridges, with only static seals on the exterior of valve cartridge **123**, replacement of valve cartridge **123** replaces all of the seals and mating valving surfaces that are subject to wear. Modern two handle fixtures also utilize separate, replaceable hot and cold water cartridges. Many modern tub/shower valve cartridges **123**, particularly the single handle designs, contain a balance piston device to sense and compensate for changes in the relative pressure levels of the hot and cold supply water, such as can occur when a toilet is flushed or a faucet is opened wide.

The replaceable valve cartridge **123** in modern control valves, an example of which is shown as **10** in FIG. **5**, communicates with hot inlet port **134**, cold inlet port **136** and discharge port **138** (shown in FIG. **6** with valve cartridge **123** removed) inside cartridge receptor **124** of valve manifold **118** through one or more fixed static seals, such as O-rings (not shown), on the exterior of valve cartridge **123**. Ports **134**, **136** and **138** form valve cartridge interface **140** inside cartridge receptor **124** that cooperates with valve cartridge **123** to transfer fluid from inlets **120** (hot) and **126** (cold) to discharges **130** (shower) and **132** (tub). In the example shown in FIG. **6**, ports **134**, **136** and **138** are positioned inside separate port cavities **142** that are configured to communicate with the end of valve cartridge **123** that is inserted inside cartridge receptor **124**. Valve cartridge **123** is appropriately and cooperatively ported to flow water from hot water line **26** and/or cold water line **22** to shower discharge **130** and tub discharge **132**. The opposite end of valve cartridge **123**, which extends generally outwardly from cartridge receptor **124**, as shown in FIG. **5**, generally includes one or more mechanisms that cooperate with flow control handle **108** for selecting the relative amount of hot and cold water and for controlling the on/off and volume of flow to shower head **100** and/or tub spout **104**, such as on/off/flow stem **146** which operatively connects to flow control handle **108** to allow the user to control the temperature and flow volume of water. For the control valve **10** shown in FIG. **5**, as an example, on/off/flow stem **146** rotates for temperature control to turn the flow of water on and off. For many older configurations, stem **146** reciprocates to control the on/off and flow rate functions and rotates to control the water temperature. Attached to, connected to or part of the typical control valve **10**, shown in FIG. **5**, are one or more escutcheon mounting mechanisms **148** that are configured to removably mount escutcheon plate **114** so as to cover wall opening **112** with escutcheon plate **114**. As shown in FIG. **5**, escutcheon mounting mechanisms **148** can comprise tab members **149** having a threaded mounting hole **150** configured to removably receive a bolt, screw or other connecting device for holding escutcheon plate **114** over wall opening **112**. Alternatively, mounting mechanism **148** can be configured with the outer end **151** of valve manifold **118** being threaded, as shown in FIG. **19**, to receive escutcheon plate **114** having a large mating hole. Typically, a large single nut then clamps escutcheon plate **114** in place. The typical valve cartridge **123** also has one or more external sealing members, such as O-rings (not shown), that cooperate with wall **152** of cartridge receptor **124**.

As known to those skilled in the art, water control valves **10** are available in many different configurations incorporating various design and operational preferences depending on the company, model, and/or desired features. Although such water control valves **10** may differ somewhat, such as various configurations for radially or axially disposed inlets and discharges, replaceable valve cartridge **123** generally has a first end (the insert end) that cooperates with valve cartridge interface **140**, having hot **134**, cold **136** and discharge **138** ports, a sealing mechanism (not shown) that cooperates with wall **152** of cartridge receptor **124** (those formed as a cavity), and a second end (the extending end) that cooperates with flow control handle **108**. The way in which these components cooperate may be somewhat different depending on the manufacturer and/or model. For instance, the positioning of hot **134**, cold **136** and discharge ports **138** at valve cartridge interface **140** generally varies by manufacturer and/or model of water control valve **10**. In some brands/models of water control valve **10**, valve cartridge interface **140** may have one or more, or all, of these ports positioned on wall **152** of the cavity that forms cartridge receptor **124** instead of on the bottom of the cavity shown in FIG. **6**. As known to those skilled in the art, however ports **134**, **136** and **138** are configured relative to cartridge receptor **124**, valve cartridge **123** is appropriately ported so as to cooperate with ports **134**, **136** and **138** of valve cartridge interface **140** so as to transfer water from hot water line **26** and/or cold water line **22** to shower line **102** and tub line **106** so as to deliver water to shower head **100** or tub spout **104**, as selected by the user through operation of flow control handle **108**, and appropriately configured to cooperate with flow control handle **108**. Valve cartridge **123** may have internal channels or external channels, which cooperate with valve receptor **124** to provide the flow path, to move the water between inlet ports **134** (hot) and **136** (cold) to discharge port **138**. Escutcheon mounting mechanisms **148** may be mounted, attached or otherwise cooperatively engaged with valve manifold **118** to secure escutcheon plate **114** over wall opening **112**. The various improvement features, such as pressure balancing, are likewise incorporated differently in water control valve **10** by the different manufacturers and/or on different models by the same manufacturer.

Complete replacement of existing water control valves **10** installed behind support wall **110** is generally impractical, as it usually requires tearing out a large section of the shower support wall **110** (including any tile or fiberglass surfaces) and physically sawing through the existing plumbing to free the old valve manifold **118**. At least a portion of the existing plumbing must then be replaced, including new union fittings added where threaded pipe is utilized. Additionally, at least a portion of support wall **110**, with tile or other water-resistant covering, must then be reinstalled. The scope of this replacement work is beyond the capability or ambition of most homeowners and the cost to hire a contractor/plumber to do the work is generally so high as to be prohibitive to the typical homeowner. As such once a particular manufacturer's water control valve **10** is installed, it is very difficult to replace that valve **10** with one by a different manufacturer or even by a different model made by the same manufacturer. One purpose is to allow retrofitting of existing water control valves **10** in tub/shower fixtures **34** with the newer features of instant hot water (i.e., through use of bypass valve **16** or others), pressure balance temperature regulation, anti-scalding and/or temperature sensitive mixing, as well as other possible features, without the need for replacing the installed/mounted component (i.e., the valve manifold **118**) of the existing water control valve **10**.

The flow control handle **108**, escutcheon plate **114** and valve cartridge **123** of the existing water control valve **10** are removed and discarded. Once these components are removed, thereby exposing valve cartridge interface **140** on or inside valve receptor **124** of valve manifold **118**, an adapter plug **170**, an example of which is shown in FIGS. **7** through **9**, can be inserted inside or against valve receptor **124**. The adapter plug **170** shown in these figures, is a simplified example of an adapter plug **170** that is configured to be utilized with a relatively larger size cavity for cartridge receptor **124**, as shown in FIG. **6**, so as to more easily illustrate and discuss the various features. As set forth in more detail below, configurations of certain valve cartridge **123** and cartridge interface **140** will require a more compact design in order to accomplish these same objectives. The intent is to provide a retrofitting system, shown as **172** in FIG. **10**, that includes an adapter plug **170** which is specifically configured for a particular make and model of existing water control valve **10**, thereby providing for its particular cartridge interface **140** and cartridge receptor **124**, so the user can then utilize a new, and typically improved, retrofit water control valve **174** to provide the desired flow control characteristics. In this manner, the user can relatively simply and quickly retrofit his or her shower/tub system **34** to include the various features that are currently available, such as the instant hot water and pressure balancing features discussed herein, without having to replace the valve manifold **118** that is fixedly installed in their water distribution system **18**. Even if the water control valve **10** of the user's existing shower/tub system **34** has these features already, the use of the retrofit system **172** allows the user the vastly improved flexibility to change from one manufacturer and/or model to another.

As shown in FIG. **10**, adapter plug **170** of retrofit system **172** hydraulically connects to retrofit valve **174**, which can be done at the time of installation unless they have been previously connected or they are configured integrally, and a modified escutcheon plate **176** and a new flow control handle **178** are utilized, as best shown in the retrofit system **172** of FIG. **10**. In one preferred embodiment, adapter plug **170** comprises a plug body **180** that is sized and configured to be received in the cavity forming valve receptor **124** with generally, but not necessarily always, one or more plug sealing members, such as the O-ring shown as **182** in FIG. **8**, disposed around the outer surface of plug body **180** to sealably interact with wall **152** of the cavity. In some configurations, no sealing members **182** will be required around plug body **180**. At the first end **184** of plug body **180**, the end which is inserted inside valve receptor **124** and placed against valve cartridge interface **140**, is first plug interface **186** that is configured to connect to and cooperate with valve cartridge interface **140** so as to transfer fluid from valve manifold **118** to retrofit valve **174**. At the second end **186** of plug body, the end which extends generally outwardly from valve receptor **124**, is second plug interface **190**. As explained in more detail below, second plug interface **190** is configured to hydraulically transfer fluid from adapter plug **170** to retrofit valve **174**. As known to those skilled in the art, plug body **180** can be made out of a variety of different materials, including various plastics, metals and composites.

For the valve manifold **118** shown in FIGS. **5** and **6**, with valve cartridge interface **140** shown in FIG. **6**, first plug interface **186** can be configured as shown in FIGS. **7** and **8**. In this configuration, first plug interface **186** comprises a first plug port **192**, second plug port **194** and third plug port **196**, each of which are disposed in a shaped spigot member **198** having a sealing member **200** (such as an o-ring) thereon for being sealably received in their respective port cavities **142** inside or on cartridge receptor **124**. As known to those skilled in the art, other configurations of valve cartridge interface **140** will not require use of spigot members **198**. When first plug interface **186** is engaged against valve cartridge interface **140**, hot inlet port **134** is hydraulically connected to first plug port **192**, cold inlet port **136** is hydraulically connected to second plug port **194** and discharge port **138** is hydraulically connected to third plug port **196** to transfer fluid between valve manifold **118** and adapter plug **170**. Second plug interface **190** includes fourth plug port **202**, fifth plug port **204** and sixth plug port **206**, as best shown in FIG. **9**, which are adapted to hydraulically connect, directly or indirectly, to retrofit valve **174**. Interconnecting the ports on first plug interface **186** to the ports on second plug interface **190** are passageways, shown as first passageway **208**, second passageway **210** and third passageway **212** in FIG. **8**. First passageway **208** interconnects first plug port **192** with fourth plug port **202** to transfer hot water to retrofit valve **174**, second passageway **210** interconnects second plug port **194** with sixth plug port **206** to transfer cold water to retrofit valve **174**, and third passageway **212** interconnects third plug port **196** with fifth plug port **204** to transfer fluid from retrofit valve **174** to discharge port **138** on valve manifold **118**, where it is transferred to shower line **102** and/or tub line **106** and then to shower head **100** and/or tub spout **104**, respectively. As set forth below, some other configurations of adapter plug **170** will not have sufficient space for three round, parallel, straight (molded or drilled) internal passageways of sufficient size to transfer the desired fluids. For these adapter plugs **170**, first **208**, second **210** and third **212** passageways must be configured differently.

Retrofit valve **174**, best shown in FIGS. **11** and **12**, has a valve body **220** that encloses a first fluid chamber **222**, best shown in the cross-sectional view of FIG. **12**, for receiving water control cartridge **224**, which is configured to be operated by flow control handle **178** to mix hot and cold water for use in retrofit system **172**. In a preferred embodiment, valve body **220** also encloses second fluid chamber **226** that is configured to receive bypass valve **16** and be in hydraulic connection with first fluid chamber **222**, as explained below. As known to those skilled in the art, water control cartridge **224** can be a specially configured water control device that is configured to provide the desired operational features or water control cartridge **224** can be an "off-the-shelf" water control device that already includes the desired features, such as pressure balancing, anti-scalding and/or temperature sensitive mixing. Various manufacturers provide water control devices, presently in the form of valve cartridges **224**, that include the pressure balancing in addition to the standard temperature mixing and on/off/flow control. One such device is Moen's Posi-Temp® cartridge. As known to those skilled in the art, pressure balancing is an important feature that maintains constant temperature even when the hot or cold water pressure varies (i.e., when the toilet is flushed, a sink valve is opened wide or other actions are taken that cause hot/cold water pressure variation), The retrofit system **172** allows the user to select a different manufacturer for the upgrade to a new valving system with the desired features, such as pressure balancing.

As best shown in FIG. **11**, retrofit valve **174** has a first valve port **228** that functions as a hot water inlet, a second valve port **230** that functions as a cold water inlet and a third valve port **232** that functions as the discharge port for discharging water to the shower head **100** and/or tub spout **104**. Generally, but not necessarily always, first **228**, second **230** and third **232** valve ports will be positioned for external access on valve body **220** of retrofit valve **174**. Generally, as with current control valves **10**, retrofit valve **174** will be sealed with an on/off/flow stem **234** of water control cartridge **224** extending therefrom to be operatively engaged by flow control handle **178**. Although retrofit valve **174** having only a first fluid chamber **222** with the new water control cartridge **224** provides advantages for the typical shower/tub system **34**, significant additional advantage can be obtained by including second fluid chamber **226** with bypass valve **16** therein for instant hot water availability. As discussed in more detail above, use of second fluid chamber **226** with bypass valve **16** therein, as shown in FIG. **12**, provides hot water in the retrofit system **172** as soon as the user desires hot water, as selected by flow control handle **178**.

In the embodiment shown in FIG. **12**, bypass valve **16** includes sealing member **236** at or near bypass valve inlet **46** and support member **238** at or near bypass valve outlet **48**. Sealing member **236** sealably interacts with valve wall **240** to close off flow from bypass channel **242**, except through bypass valve **16**, that interconnects first valve port **228** through which hot water is received in second fluid chamber **226**. Sealing member **236** can be an O-ring mounted externally to bypass valve **16** or other like devices that are sufficient for preventing flow around bypass valve **16**. Support member **238** should be sized and configured to support and center bypass valve **16** inside second fluid chamber **226**. Second valve port **230**, which connects to cold water line **22**, can be positioned directly over cold water channel **244** or second fluid chamber **226**. Under normal operating conditions (i.e., non-bypassing), hot or cooled off water enters retrofit valve **174** at first valve port **228** and cold water enters retrofit valve **174** at second valve port **230**. The hot and cold fluids are mixed by water control cartridge **224**, as selected by the user through operation of flow control handle **178**, and then directed to third valve port **232** for discharge to, ultimately, shower head **100** and tub spout **104**. Under the normal, non-bypassing condition hot water will wash across the face of screen **60** to clean it of any debris that collects thereon during bypass operations, making screen **60** self-cleaning. During bypass conditions, which occurs when the water in hot water line **26** (as determined at bypass valve inlet **46** in bypass channel **242**) is cold or tepid, bypass valve **16** allows the cold or tepid water to flow through bypass valve **16**, exit bypass valve outlet **48** and flow out retrofit valve **174** at second valve port **230** into, ultimately, cold water line **22**. This "reverse" water flow through the cold water line **22** is accomplished by the pressure deferential supplied by pump **32**, or other pressurizing means, in water distribution system **18**. As soon as the water in bypass channel **242** reaches the desired hot temperature, bypass valve **16** closes, thereby preventing the hot water from flowing through bypass valve **16**, returning retrofit system **172** to the normal operating condition (non-bypassing).

In a preferred embodiment, shown in FIG. **12**, retrofit valve **174** is configured such that both water control cartridge **224** and bypass valve **16** can be replaced without having to replace or remove retrofit valve **174** from retrofit system **172**. As shown, this can be accomplished by providing retrofit valve **174** with a first opening **246** and a second opening **248** that open into first fluid chamber **222** and second fluid chamber **226**, respectively. As best shown in FIG. **13** (which is Moen's model 1222 Posi-Temp® cartridge), water control cartridge **224**, having a first end **252** and a second end **256**, is provided with a first sealing member **254** at second end **256** so that water control cartridge **224** can be sealably placed inside first fluid chamber **222** (with first end **252** inserted first). The hot port on water control cartridge **224** is sealed to bypass channel **242** with cylindrically curved face seal **250**. The cold port on water control cartridge **224** is sealed to cold water channel **244** with cylindrically curved face seal **251**. This effectively isolates these ports from first fluid chamber **222**. The discharge zone **255** between sealing member **254** and the two face seals **250** and **251** is the tub/shower discharge. Sealing member **254** can be an O-ring or other type of sealing mechanisms known to those skilled in the art. As known in the art, such as with many currently available valve cartridges **123** and water control cartridges **224**, sealing member **254** should be configured to close off first fluid chamber **222** and prevent the flow of water out first opening **246**. In the embodiment shown in FIG. **12**, bypass valve **16** is inserted into second fluid chamber **226** through second opening **248** and a cap member **258** is utilized to close off second opening **248** into second fluid chamber **226**. In one embodiment, cap member **258** comprises a threaded end **260** that is threadably received in second opening **248** and a cap sealing member **262**, such as an O-ring, that provides a static seal to prevent fluid from flowing out retrofit valve **174** through second opening **248**. As known to those skilled in the art, various other sealing mechanisms and closure mechanisms can be utilized to close bypass valve **16** and water control cartridge **224** inside retrofit valve **174**. Alternatively, once these components are placed inside their respective fluid chambers, first **246** and second **248** openings can be fixedly closed. In another alternative, it may be possible and advantageous to manufacture retrofit valve **174** with all or a majority of the components of bypass valve **16** and/or water control cartridge **224** made integral with valve body **220**.

As set forth above, various existing water control cartridges **224** made by various manufacturers could be suitable for use with retrofit valve **174**. One such water control cartridge is shown in retrofit valve **174** in FIG. **12** and alone in FIG. **13**. As known to those skilled in the art, this water control cartridge **224** includes a pressure balance feature that maintains the relative pressure between the hot and cold water flow when a the water distribution system **18** is subject to a sudden change in water pressure in the hot or cold water lines (i.e., as when a toilet is flushed or a water faucet is open wide). Water control cartridges having pressure balancing features have been known for many years. For instance, U.S. Pat. No. 2,308,127 to Symmons, U.S. Pat. No. 4,033,370 to Egli, U.S. Pat. No. 4,469,121 to Moen and U.S. Pat. No. 6,361,051 to Babin show various pressure balance configurations.

As also know to those skilled in the art, an anti-scalding device can be incorporated to provide instant water shut-off if the temperature of the water exceeds a pre-set level. Although various manufacturers make such devices (typically they are utilized in shower head **100**), they generally include a reset button to allow the user to manually resume water flow after the device is automatically activated. Such a device can be included in retrofit valve **174**, in addition to or instead of the pressure balancing feature discussed above, to block the flow of mixed water from retrofit valve **174** if the water temperature is too high (above the preset level). The reset button can be configured to protrude through retrofit valve **174** to be accessible to the user to resume fluid flow. Another possible improvement, which can be utilized in addition to or instead of water control cartridge **224** with the pressure balancing feature, is an anti-scalding, proportional thermostatic water mixing and diverting valve (such as the Aquamix® available from Sparco, Inc. of Warwick, R.I.) that is a temperature sensitive mixing valve, as opposed to pressure sensitive, to maintain the water at or near a desired temperature under varied operating conditions (i.e., toilet flushing, sink valve opened, etc.). As such, the device provides both anti-scalding and anti-chilling through simultaneous control of the hot and cold water. The components of such a valve can be configured to fit inside of retrofit valve **174** to provide this feature to an existing water control valve **10** having valve manifold **118**.

Use of the valve with a different model of control valve **10** is illustrated in FIGS. **14** through **17**. One type of older design for valve manifold **118**, shown in FIG. **14**, has a longer, narrower cartridge receptor **124** than that illustrated in FIGS. **5** and **6**, that is configured to cooperatively receive a longer, narrower valve cartridge **123**. FIGS. **15** and **16** show an adapter plug **170** suitable for use with the valve manifold **118** shown in FIG. **14**. As with current valve cartridges **123**, adapter plug **170** includes one or more static seals, such as first static seal **300**, second static seal **302** and third static seal **304** to isolate portions of adapter plug **170** to facilitate flow from/to hot inlet port **134**, cold inlet port **136** and discharge port **138**. As shown in FIGS. **16** and **17**, an upper section **306** generally towards second end **188** of adapter plug **170** includes fourth plug port **202**, fifth plug port **204** and sixth plug port **206** and is configured to generally extend outwardly from cartridge receptor **124**, Lower section **308**, generally towards first end **186** of adapter plug **170**, is configured to be inserted into cartridge receptor **124** with first static seal **300** preventing fluid from flowing out cartridge receptor **124**. Second static seal **302** isolates third plug port **196**, which is in hydraulic communication with discharge port **138**. Third static seal **304** separates first plug port **192** and second plug port **194**, which are in hydraulic communication with hot inlet port **134** and cold inlet port **136**, respectively. As shown in FIG. **16**, internally adapter plug **170** comprises an inner, first tube **310** and a second tube **312** around first tube **310** to form first passageway **208** for the flow of hot water (or cooled/tepid water as the case may be), second passageway **210** for the flow of cold water and third passageway **212** for the flow of discharge water to, ultimately, shower head **100** and tub spout **104**. In one embodiment plug body **180** comprises a two-piece stationary cylindrical sleeve.

Connecting adapter plug **170** inside valve manifold **118** with retrofit valve **174** are one or more fluid connectors **272** comprising a first conduit **274**, second conduit **276** and third conduit **278**, as shown in FIGS. **10** and **17**. FIG. **17** shows adapter plug **170** as configured for an alternative design of tub/shower valve **10**, shown in FIGS. **14**, **15** and **16** and discussed above. First conduit **274** interconnects fourth plug port **202** to first valve port **228** to deliver the hot water (which may be cold or tepid) to retrofit valve **174**. Second conduit **276** interconnects sixth plug port **206** to second valve port **230** to deliver cold water to retrofit valve **174** and to transfer the bypassed cold or tepid water away from retrofit valve. Third conduit **278** interconnects fifth plug port **204** to third valve port **232** to transfer water from retrofit valve **174** to, ultimately, shower head **100** and/or tub spout **104**. In a preferred embodiment, three separate fluid connectors **272** are utilized, each one a rigid or conformable (i.e., flexible) tubular member. Alternatively, the valve can utilize a single fluid connector **272** that has first **274**, second **276** and third **278** conduits incorporated therein. As discussed in more detail below, fluid connectors **272** facilitate the placement of retrofit valve **174** behind escutcheon plate **176** by allowing for axial variation of its positioning, which may often be controlled by the other shower/tub components. Whether rigid or conformable, fluid connectors **272** can be made out of plastic, copper or various other metallic or non-metallic materials. For rigid fluid connectors **272**, the ends thereof, which connect to second plug interface **190** of adapter plug **170** and to first **228**, second **230** and third **232** valve ports on retrofit valve **174**, can be configured to be removably attached to their respective ports. As an example, both ends of fluid connectors **272** can be configured to have an angularly adjustable, sealable end, such as can be achieved by utilizing spherical ends (shown as **280** for one end only in FIG. **17**) fitted into hemispherical sockets, which are shown as **282** on FIGS. **8** and **9** for second plug interface, that are clamped and sealed with gland plates (not shown). This type of arrangement would allow the positioning of retrofit valve **174** to "float" with respect to accessible second plug interface **190** of adapter plug **170** during installation until the fasteners holding the gland plates are tightened, thereby clamping and sealing the adjustable joints at both ends of fluid connectors **272**. Alternatively, one end of fluid connectors **272** can be fixedly attached to either adapter plug **170** or retrofit valve **174**, as shown in FIG. **17** for the end attached to retrofit valve **174**.

Although it is possible to configure the retrofit system **172** such that both ends of fluid connectors **272** are fixedly attached to adapter plug **170** and retrofit valve **174**, particularly with the use of flexible fluid connectors **272** to allow positioning of retrofit valve **174** during installation, this will generally not be the preferred configuration due to the loss of interchangeability with regard to different makes and models of water control valves **10**. If it is desired to provide a retrofit system **172** that is configured for only a particular make/model of water control valve **10**, then the system could be provided with a single adapter plug **170** and retrofit valve **174** for that make/model of control valve **10**. In fact, if system flexibility is not necessary or desired, retrofit valve **174** can be configured to abut or otherwise directly connect first **228**, second **230** and third **232** valve ports to fourth **202**, sixth **206** and fifth **204** plug ports, respectively, with very short fluid connectors **272**. In such cases, adapter plug **170** and retrofit valve **174** may be made as one integral component. Otherwise, it will generally be preferred to maintain interchangeability of retrofit system **272** by allowing use of a variety of differently configured adapter plugs **170** for differently configured water control valves' **10**, which can best be achieved by having at least one end of fluid connectors **272**, preferably the end that attaches to adapter plug **170**, releasably connect to the other component (i.e., as shown in FIG. **17**). As known to those skilled in the art, the releasable connection can be achieved by various mechanisms, including threaded ends and the like.

As shown in FIG. **10** and discussed above, adapter plug **170** is configured to be received inside or on valve manifold **118** and retrofit valve **174** is positioned relatively near adapter plug **170**, both of which are located behind escutcheon plate **176**. To accommodate the increased axial displacement, relative to cartridge receptor **124**, escutcheon plate **176** has an outwardly extending blister portion **284**, as shown in FIG. **10**. As known in the art, the axial placement of the existing installed shower valve manifold **118** with respect to the plane of the shower/support wall **110** varies from one old installation to another, generally depending on plumbing tolerances and the whim of the installing plumber. Later renovations, such as the addition of tile or shower stall panels, will also cause major variation with regard to the axial location of cartridge receptor **124** relative to support wall **110**. These variations will cause the axial location, from the plane of support wall **110**, of the accessible end of adapter plug **170** (i.e., second plug interface **190**), to likewise vary. Preferably, retrofit valve **174** should be at some fixed location with respect to the plane of support wall, which would preferably be against or very near support wall **110** to allow the use of escutcheon plate **176** having the shallowest possible depth for blister **284** so that it will not intrude as far into the shower/tub space. Because most modern water control cartridges **224** are longer than wide, it is likely to be preferred that retrofit valve **174** be positioned such that the axial direction of water control cartridge **224** is generally parallel to the plane of surface wall **110** and thus perpendicular to adapter plug **170**. In this configuration, retrofit valve **170**, as well as escutcheon plate **176**, can be attached to and physically supported by support wall **110**. This will provide a rigid and sturdy support for flow control handle **178**, which is attached to stem **234**, which the user will actuate to control the temperature and flow of water from shower head **100** and tub spout **104**. Connecting retrofit valve **174** and/or escutcheon plate **176** directly to valve manifold **118** and/or adapter plug **170** (with their varying axial protrusions) presents many difficulties, particularly with regard to the need to install escutcheon plate **176** substantially flush against support wall **110**.

In a preferred embodiment, retrofit system **172** will utilize bracket **290** for securely mounting and positioning retrofit valve **174** and escutcheon plate **176** relative to adapter plug **170**, as shown in FIGS. **18** through **21**. Additional physical support may be gained by utilizing an adhesive or other attachment mechanism to attach to wall **110**. In one configuration, best shown in FIGS. **18** and **19**, bracket **290** is configured with one or more first bracket members **292** that attach to escutcheon mounting mechanisms **148** associated with valve manifold **118** of the existing water control valve **10**. As stated above, mounting mechanisms **148** are generally attached to, part of, connected to or cooperating with valve manifold **118**, as shown in FIGS. **18** and **19**. Bracket **290** can also be configured with one or more second bracket members **294** that are configured to provide a support for securely attaching retrofit valve **174** and/or escutcheon plate **176**. As shown in FIG. **20**, second bracket member **294** can be configured with one or more mounting holes **296** to receive an attachment mechanism, such as a screw or bolt, to hold retrofit valve **174** and escutcheon plate **176** in place. In one configuration, retrofit valve **174** attaches to second bracket member **294** and escutcheon plate **176** attaches to one or more lugs (not shown) on retrofit valve **174**. The preferred embodiment of bracket **290** also includes an adjustment mechanism **298** that is configured to allow the user to adjust the axial displacement (i.e., distance from wall) for retrofit valve **174** and escutcheon plate **176**. In one well known configuration, adjustment mechanism can comprise a plurality of elongated holes and screws in second bracket member **294** that cooperate with a like number of holes, not elongated, in first bracket member **292** to allow the installer to slide second bracket member **294** forwards and backwards to obtain the position he or she desires. Although bracket **290** can be manufactured out of a variety of different materials, including metals, plastic, composites and the like, a sturdy metal bracket **290** is likely preferred to provide the support necessary for the user to utilize flow control handle **178** without flexing or breaking bracket **290**.

Escutcheon plate **176**, like the existing escutcheon plate **114**, is configured to cover the opening **112** in support wall. In addition, as stated above, escutcheon plate **176** includes blister **284** to provide an enclosure for the accessible portion of adapter plug **170** (i.e., the second plug interface **190**), retrofit valve **174**, fluid connectors **272** and bracket **290**. Retrofit system **172** can include a single, uniform escutcheon plate **176** that is suitable for most, if not all, retrofit systems **172**, thereby adding to the uniformity of retrofit system **172**. A hole (not shown) should be provided in escutcheon plate **176**, for instance in the blister **284**, for on/off/flow stem **234** to extend through so that it may connect to flow control handle **178**. Shower systems **34** having two handle valves will require a different configuration for escutcheon plate **176**. Escutcheon plate **176** can be made out of a variety of materials, such as brass, plated steel, stainless steel and/or zinc, as desired for the consumer's shower system **34**.

Flow control handle **178** is configured to actuate retrofit valve **174** so as to allow the user to control the temperature) volume and on/off of water through shower head **100** and/or tub spout **104**. As stated above, stem **234** will protrude through escutcheon plate **176** (i.e., blister **284**). A short lever-like flow control handle **178**, as shown in FIG. **10**, attached to stem **234** will allow approximately 180 degrees of rotation to accomplish the on/off and temperature adjustment of retrofit valve **174**. In one embodiment, the plane of motion for the flow control handle **178** will be perpendicular to support wall **110** and in either a vertical or horizontal plane, depending on whether a vertical or horizontal orientation of retrofit valve **174** is deemed to provide the most aesthetically pleasing appearance for blister **284** and the most natural manual motion to actuate retrofit valve **174**. Preferably, the length of flow control handle **178** is kept relatively short to limit encroachment in the shower/tub space, such as that common with existing shower control valves **10**.

To retrofit an existing shower/tub fixture **34** to obtain the features of the retrofit system **172**, the person installing the system **172** turns off the water supply to the house or other facility and removes the existing flow control handle **108** and escutcheon plate **114** to expose valve manifold **118** mounted in the water distribution system **18**. Unlike prior art replacement of water control valve **10**, there is no need for the user to remove or replace the existing valve manifold **118**. The user removes valve cartridge **123** from valve receptor **124**, which is typically a cavity as shown, of valve manifold **118** to expose valve cartridge interface **140**. Flow control handle **108**, escutcheon plate **114** and valve cartridge **123** can be discarded. Adapter plug **170**, configured for the particular type of valve manifold **118** and valve cartridge interface **140** installed in water distribution system **18**, is inserted into or against cartridge receptor **124** such that first plug interface **186** hydraulically connects to valve cartridge interface **140**. If necessary, adapter plug **170** is secured in place with a screw, I bonnet ring or other fasteners. The user then mounts bracket **290** to at least one of the one or more mounting mechanisms **148** associated with valve manifold **118**. In some configurations, bracket **290** may be installed with adapter plug **170** or it may have its own fastening method and hardware. In other configurations, adhesives or other attachment mechanisms may be utilized, The user then connects the one or more fluid connectors **272**, which has a first conduit **274**, second conduit **276** and third conduit **278** and may be compliant or rigid, between second plug interface on adapter plug **170** and first, **228**, second **230** and third **232** valve ports on retrofit valve **174** to hydraulically interconnect adapter plug **170** and retrofit valve **174**. In some configurations, one or both ends of the elongated fluid connectors **272** may be fixedly attached to either or both of adapter plug **170** and/or retrofit valve **174**. If universality is not desired, such that it is configured to replace a particular make and model of water control valve **10**, then both ends of fluid connectors **272** can be fixed (i.e., one end to adapter plug **170** and the other end to retrofit valve **174**). If retrofit valve **174** is provided separate from bracket **290**, then the user secures retrofit valve **174** to bracket **290**, preferably adjusting the installation so the axial centerline of retrofit valve **174** is substantially parallel to support wall **110** and placed against or spaced apart from support wall **110** per instructions for the particular configuration. Bracket **290** or retrofit valve **174** may be adhesively or otherwise attached to wall **110**. If necessary, the installer then secures all compliant or adjustable ends of fluid connectors **272** (i.e., those having gland devices or other fasteners) to seal the ends of fluid connectors to the respective adapter plug **170** and/or retrofit valve **174**. The new escutcheon plate **176** is then mounted to bracket **290** such that the blister portion **284**, if any, covers the exposed end of adapter plug **170** and retrofit valve **174** and stem **234** of water control cartridge **224** in retrofit valve **174** extends generally outwardly through escutcheon plate **176**. The user then attaches, typically using a setscrew or other type of fastener, the new flow control handle **178** to stem **234** to provide operational control to retrofit valve **174**. The user then should be able to operate his or her retrofit system **172** with the enhanced features of the new retrofit valve, such as instant hot water provided by bypass valve **16** and/or pressure balancing. All of which is accomplished without removing or replacing the existing valve manifold that is fixedly mounted in the water distribution system.

With regard to the use of a thermostatically controlled bypass valve **16** having the components shown in FIGS. **2** through **4** and described in the accompanying text, the operation of the bypass valve **16** is summarized on the chart shown as FIG. **22**. The chart of FIG. **22** summarizes the results of the twenty combinations of conditions (pump on/pump off; hot water line hot/hot water line cooled off; hot water valve fully open, closed or between; cold water valve fully open, closed or between) that are applicable to the operation of bypass valve **16**. The operating modes IVB, IVC, IVD, IIIB, & IIID are summarized detailed in the immediately following text. The operation of the remaining fifteen modes are relatively more obvious, and may be understood from the abbreviated indications in the outline summarizing FIG. **22**.

Starting with the set "off hours (normal sleeping time, and daytime when no one is usually at home) pump **32** will not be powered. Everything will be just as if there were no pump **32** and no bypass valve **16** in use with retrofit valve **174** (i.e., both the cold and hot water lines will be at the same city water pressure). The water in hot water line **26** and at bypass valve **16** will have cooled off during the long interim since the last use of hot water. The reduced water temperature at bypass valve **16** results in "retraction" of rod member **76** of the thermally sensitive actuating element **54**. The force of bias spring **56** pushing against flange **82** on rod member **76** will push it back away from valve seat **68**, opening bypass valve **16** for recirculation. Although the thermal actuating element **54** is open, with pump **32** not running, no circulation flow results, as the hot **26** and cold **22** water lines are at the same pressure. This is the mode indicated as IVB in the outline on FIG. **22**. If the cold water valve at retrofit valve **174** is opened, with thermal actuating element **54** open as in mode IVB above, pressure in cold water line **22** to the cold water side of retrofit valve **174** will drop below the pressure in hot water line **26**. This differential pressure will siphon tepid water away from the hot side to the cold side, which is the mode indicated as IVD in the outline on FIG. **22**. The recirculation of the "hot" water will end when the tepid water is exhausted from the hot water line **26** and the rising temperature of the incoming "hot" water causes actuating element **54** to close.

If the hot water side of retrofit valve **174** is turned on with actuating element **54** open as in mode IVB above, pressure in hot water line **26** will drop below the pressure in cold water line **22**. This differential pressure, higher on the cold side, will load check valve **64** in the "closed" direction allowing no cross flow. This is mode IVC in the outline on FIG. **22**. In this mode, with hot water line **26** cooled and pump **32** off, a good deal of cooled-off water will have to be run Gust as if bypass valve **16** were not installed), to get hot water, at which time actuating element **54** will close without effect, and without notice by the user. With actuating element **54** open and hot water line **26** cooled-off as in mode IVB above, at the preset time of day (or when the cyclic timer trips the next "on" cycle) pump **32** turns on, pressurizing the water in hot water line **26**. Pump pressure on the hot side of retrofit valve **174** results in flow through the open actuating element **54**, thereby pressurizing and deflecting check valve **64** poppet away from its seat to an open position. Cooled-off water at the boosted pressure will thus circulate from the hot line **26** through actuating element **54** and check valve **64** to the lower pressure cold water line **22** and back to water heater **24**. This is the primary "working mode" of the bypass valve **16** and is the mode indicated as IIIB in the outline on FIG. **22**. If the cold water valve is turned on during the conditions indicated in mode IIIB above (i.e., pump **32** operating, hot water line **26** cooled off, and the hot water valve at retrofit valve **174** turned off) and while the desired recirculation is occurring, mode IIID will occur. A pressure drop in the cold water line **22** due to cold water flow creates a pressure differential across valve **16** in addition to the differential created by pump **32**. This allows tepid water to more rapidly bypass to cold water line **22**. When the tepid water is exhausted from hot water line **26**, actuating element **54** will close, ending recirculation.

Explanation of FIG. **22** Table

Mode I: Water in Hot Water Supply Line Hot, Pump on.

A. Hot and cold water valves fully open. Pressure drops from hot and cold flow about equal. Actuating element **54** stays closed. No leak or recirculation in either direction.

B. Hot and cold water valves fully closed. Actuating element **54** keeps bypass valve **16** closed. No recirculation.

C. Hot water valve fully open, cold water valve closed. Actuating element **54** closed. Check valve **64** closed. No recirculation. No leak.

D. Hot water valve closed, cold water valve fully open Actuating element **54** closed. No recirculation. No leak.

E. Hot and cold water valves both partially open in any combination Actuating element **54** closed. No recirculation. No leak.

Mode II: Water in Hot Water Supply Line Hot, Pump Off.

A. Hot and cold water valves full on. Pressure drops from hot and cold flow about equal. Actuating element **54** stays closed.

B. Hot and cold water valves fully closed. Actuating element **54** keeps bypass valve **16** closed. No recirculation.

C. Hot water valve fully open, cold water valve closed. Actuating element **54** closed. Check valve **64** closed. No recirculation. No leak.

D. Hot water valve closed, cold water valve fully open Actuating element **54** closed. No recirculation. No leak.

E. Hot and cold water valves both partially open in any combination. Actuating element **54** closed. No recirculation. No leak.

Mode III: Water in Hot Water Line Cooled Off, Pump on.

A. Hot and cold water valves full open. Flow-induced pressure drops about equal, bypass valve **16** stays open and allows recirculation hot to cold until tepid water is exhausted and hotter water closes actuating element **54**. If both sides of water control valve are discharging to the same outlet they are mixing hot and cold anyway. If the valves being manipulated are at remote fixture on the same plumbing branch, this short time tepid-to-cold leak will probably not be noticeable. If valves being manipulated are on remote branches of plumbing, the mixing would have no effect.

B. Hot and cold water valves fully closed. Actuating element **54** open, get desired tepid-to-cold recirculation until hot water line **26** heats up.

C. Hot water valve fully open, cold water valve closed. Actuating element **54** open but pressure drop in hot water line **26**~negate pump pressure, stopping recirculation. Check valve **64** stops cold to hot leak.

D. Hot water valve closed, cold water valve fully open. Actuating element **54** open, get tepid to cold recirculation until hot line heats up.

E. Hot and cold water control valves both partially open in any combination. Could get tepid to cold leak. If valves are at same fixture don't care as mixing hot and cold anyway. If at remote fixture probably not noticeable. Tepid to cold leak would be short term.

Mode IV: Water in Hot Water Supply Line Cooled Off, Pump Off.

A. Hot and cold water valves full open. Flow-induced pressure drops about equal, bypass valve **16** stays open and may allow recirculation (leak) hot to cold until tepid water is exhausted and hotter water closes actuating element **54**. Don't care, if both valves are at same fixture as are mixing hot and cold anyway. If water control valves being manipulated are at remote fixtures on the same plumbing branch, this short time tepid-to-cold leak would probably not be noticeable. If water control valves being manipulated are on remote branches of plumbing, mixing would not be noticeable.

B. Hot and cold water valves fully closed. Actuating element **54** open, no recirculation.

C. Hot water valve fully open, cold water valve fully closed Actuating element **54** open. Check valve **64** closed. No leak

D. Hot water valve closed. Cold water valve fully open. Bypass valve **16** open, tepid to cold recirculation until actuating element **54** heats up and closes.

E. Hot and cold water valves both partially open, in any combination.

Could get tepid to cold leak. If water control valves at same fixture, don't care as mixing hot and cold anyway. If at remote fixture probably not noticeable. Tepid to cold leak would be short term.

Several further enhancements have been developed for the thermal valve actuating element **54**, which are applicable to the above-described bypass valve **16** are shown in FIG. **23**. It has been noted that "lime" or "calcium" buildups on piston **80** can cause sticking of piston **80** in actuating element **54**. Manufacturers of these actuating elements **54** recommend use of an elastomer boot or a nickle-teflon coating on piston **80**, or use of a plastic piston **80**. A preferred material may be use of a plastic piston **80**, to which the buildup could not get a tenacious hold, and the removal of the internal chamfer at the open end of guide bore **320** and replacement with a sharp corner **322**, as shown in FIG. **23**. Removal of the chamfer and replacement with corner **322** would provide a sharper scraping edge to clean piston **80**, and would eliminate a place where the detritus could become wedged. In addition to the chamfer removal, another simple geometry change to piston **80** might be very effective. As shown in FIG. **23**, a long shallow groove **324** in or a reduced diameter of piston **80** that would extend from just inside guide bore **320** (at full extension) to just outside guide bore **320** at full retraction would provide a recess to contain buildup for a long period. Once this recessed area filled up with lime, edge **322** of guide bore **320** could scrape off the incrementally radially extending soft build up relatively easily, as compared to scraping off the surface layer that bonds more tenaciously to the metal.

The most direct method to overcome sticking due to mineral buildup is to optimize actuator force in both directions. Buildup of precipitated minerals on the exposed outside diameter of the extended piston **80** tends to prevent retraction, requiring a strong bias spring **56**. This high bias spring force subtracts from the available extending force however, thereby limiting the force available to both extend piston **80** against the mineral sticking resistance and to effect an axial seal between poppet **78** and seat **70**. When water temperature is high, piston **80** is extended so that its surface is exposed. Deposition also occurs primarily at high temperatures, so that buildup occurs on piston **80** outside diameter, resulting in sticking in the extended position when the growth on the piston outside diameter exceeds guide **320** interior diameter. Significantly more than half of the available actuator force thus can most effectively be used to compress bias spring **56**, resulting in a maximum return force.

FIGS. **24** through **30** illustrate an alternative embodiment of a bypass valve that is designated generally as **311**. As best shown in FIGS. **24** through **26**, bypass valve **311** comprises a valve body **313** having a first end **315**, a second end **309** and a separating wall **309** disposed between first end **315** and second end **309**. First end **315** is designated to receive and discharge hot water and second end **309** is designated to receive and discharge cold water from a source of cold water, such as a city water supply system or a local water well. Valve body **313** has four threaded ports, an axial and radial port at the first end **315** and an axial and radial port at the second end **309**. For purposes of discussion herein, the axial ports are designated as inlet ports and the radial ports are designated as discharge ports, however, it will be understood from the discussion set forth below that the valve is not so limited.

At the first end **315** (the hot water side) is first inlet port **319** and first discharge port **321** and at the second end **309** (the cold water side) is second inlet port **323** and second discharge port **325**. Conversely, the radial ports can be the inlet ports and the axial ports can be the discharge ports. As discussed in detail below, the first **319** and second **323** inlet ports connect to the hot and cold water distribution system and first **321** and second **325** discharge ports connect to the hot and cold water valves on the fixture (i.e., sink, shower, bathtub or etc.) with which the bypass valve **311** is utilized. The use of both an inlet **319** and discharge **321** ports on the hot side distinguish the bypass valve **311** from other known bypass valves, which utilize a single port, and provide significant benefits for bypass valve **311**. The bypass valve **311** reduces the number of plumbing fittings (at least one tee) and plumber time for installation by allowing it to be connected simply with swivel nut hoses. Because the "tee" function is internal to valve body **313**, hot water flowing to the open fixture valve flows through valve body **313**, around the thermal actuator body, allowing immediate response to rising temperature. Conversely, if the tee is an external pipe fitting remote from the thermal bypass valve, response will be slowed. This use of an integral tee shortens time in which water can be siphoned from cold to hot, eliminating the need for an internal check valve. Hot water flowing through valve body **313** to an open fixture also allows placement of a screen inside the valve body **313** such that it is swept clean. The use of the second port on the hot side also allows placement of a retaining pin without the need for an extra seal. The use of two ports on the cold side (i.e., inlet port **323** and discharge port **325**) also eliminates the use of an external tee and further simplifies and reduces the cost of installing the bypass valve **311**. In addition, two ports on the cold side also facilitate the use of a retaining slot for holding a check valve, if one is used.

As best shown in FIG. **25** and discussed in more detail below, valve body **313** houses a thermally sensitive actuating element **326**, bias spring **328**, an over-travel spring **330**, screen **332**, retaining pin **334** and check valve **336**. Valve body **313** can most economically and effectively be manufactured out of a molded plastic material, such as Ryton®, a polyphenylene sulphide resin available from Phillips Chemical, or a variety of composites. Molded plastic materials are preferred due to their relatively high strength and chemical/corrosion resistant characteristics while providing the ability to manufacture the valve body **313** utilizing injection molding processes with the design based on the configuration described herein without the need for expensive casting or machining. Alternatively, valve body **313** can be manufactured from various plastics, reinforced plastics or metals that are suitable for "soft" plumbing loads and resistant to hot chlorinated water under pressure. As shown in FIGS. **25** and **26**, first end **315** of valve body **313** is molded with wall **309** having a passage **337** therein interconnecting first end **315** and second end **309** to allow fluid to flow therethrough, a set of axially oriented fin guides **338** having ends that form an internal shoulder **340** inside valve body **313** for fixedly receiving and positioning one end of thermal actuating element **326** and the bias spring **328**, and a retaining pin hole **344** for receiving retaining pin **334**. Second end **309** is molded with retaining slot **346** for engagement with the snap-in check valve **336**. The valve body **313** is designed so the components can fit through either of the inlet and/or discharge ports, which will typically be one-half inch diameter. In this manner, a one piece bypass valve **311** results with no intermediate or additional joints required for installation.

For ease of installation of the bypass valve **311** by the user, each of the four ports (**319**, **321**, **323** and **325**) on valve body **313** have one-half inch straight pipe threads for use with the swivel nuts that are commonly found on standard connection hoses that fit the typical residential faucet. As illustrated in FIGS. **27** and **28**, the threads on all four ports are molded with flats or axial slots **348** interrupting the threads to prevent a user from attempting to mount valve body **313** directly to "hard" plumbing with female taper pipe threads. The swivel nuts on the connection hoses seal with hose washers against the ends of the four ports, as opposed to common pipe fittings that seal at the tapered threads. These four ports can be marked "hot in", "hot out", "cold in", and "cold out" as appropriate to provide visual indicators for the do-it-yourself installer so as to avoid confusion. In the preferred installation of bypass valve **311**, inlet port **319** connects to the hot water angle stop at the wall and the discharge port **321** connects to the hot water faucet. Inlet port **323** connects to the cold water angle stop and discharge port **325** connects to the cold water faucet. In actuality, the two hot hoses can be interchanged on the two hot ports (ports **319** and **321**), as can the two cold hoses on the cold ports (ports **323** and **325**).

Thermally sensitive actuating element **326** is preferably of the wax filled cartridge type, also referred to as wax motors, having an integral piston/poppet rod member **350**, as best shown in FIG. **29**. The actuating element **326** may be substantially similar to the actuating element **54** illustrated above in FIG. **4**. Rod member **350** comprises poppet **351** attached to piston **352** with an intermediate flange **353** thereon. The end of poppet **351** seats against valve seat **342** to close passage **337**. The body **354** of actuating element **326** has a section **356** of increased diameter to seat against shoulder **340** in valve body **313**. As shown in FIG. **25**, over-travel spring **330** abuts against first side **358** of actuator body **354** and second side **360** of actuator body abuts against shoulder **340**. Piston **352** of rod member **350** interconnects poppet **351** with actuator body **354**. Actuating element **326** operates in a conventional and well known manner. Briefly, actuating element **326** comprises a wax or a mixture of wax and metal powder (i.e., copper powder) enclosed in actuator body **354** by means of a membrane made of elastomer or the like. Upon heating the wax or wax with copper powder mixture slowly expands, thereby pushing piston **352** and poppet **351** of rod member **350** in an outward direction. Upon cooling, the wax or wax/copper powder mixture contracts and rod member **350** is pushed inward by bias spring **328** until flange **353** contacts actuator body **354** at actuator seat **364**. Although other types of thermal actuators, such as bimetallic springs and memory alloys (i.e., Nitinol and the like) can be utilized, the wax filled cartridge type is preferred because the wax can be formulated to change from the solid to the liquid state at a particular desired temperature. The rate of expansion with respect to temperature at this change of state is many times higher, resulting in almost snap action of the wax actuating element **326**. The temperature set point is equal to the preset value, such as 397 degrees Fahrenheit, desired for the hot water. This is a "sudden" large physical motion over a small temperature change. As stated above, this movement is reacted by bias spring **328**, which returns rod member **350** as the temperature falls.

Although not entirely demonstrated in early tests, it is believed that beneficial "toggle" action can be achieved with a bypass valve **311** of very simple mechanical design. If the motion of the thermal actuator **326** is made to lag behind the temperature change of the water surrounding it by placing suitable insulation around the actuator **326** or by partially isolating it from the water, then instead of slowly closing only to reach equilibrium at a low flow without reaching shutoff, the water temperature will rise above the extending temperature of the insulated actuator **326** as the valve approaches shutoff, and the piston **350** will then continue to extend as the internal temperature of the actuator **326** catches up to its higher surrounding temperature, closing the valve **311** completely. It is also believed that an insulated actuator **326** will be slow opening, its motion lagging behind the temperature of the surrounding cooling-off water from which it is insulated. When actuating element **326** finally begins to open the valve **311** and allow flow, the resulting rising temperature of the surrounding water will again, due to the insulation, not immediately affect it, allowing the bypass valve **311** to stay open longer for a complete cycle of temperature rise. Such an "insulated" effect may also be accomplished by use of a wax mix that is inherently slower, such as one with less powdered copper or other thermally conductive filler. An actuator **326** to be installed with insulation can be manufactured with a somewhat lower set point temperature to make up for the lag, allowing whatever valve **311** closing temperature desired.

Also inside valve body **313** is an over-travel spring **330**, disposed between the first side **358** of the actuator body **354** and a stop located inside valve body **313** to prevent damage to a fully restrained actuator **326** heated above the bypass valve's **311** maximum operating temperature and to hold the actuator **326** in place during operation without concern for normal tolerance. Over-travel spring **330** allows movement of the actuator body **354** away from the seated poppet **351** in the event that temperature rises substantially after the poppet **351** contacts seat **342**. Without this relief, the expanding wax would distort its copper can, destroying the calibrated set point. The over-travel spring **330** also holds the bias spring **328**, rod member **350** and actuator body **354** in place without the need to adjust for the stack-up of axial tolerances. Alternatively, actuator **326** can be fixedly placed inside valve body **313** by various mechanisms known in the art, including adhesives and the like. Over-travel spring can be held in place by various internal configurations commonly known in the art, such as a molded seat. In the preferred embodiment, however, over-travel spring **330** abuts against screen **332**, which is held in place by cantilevered retention pin **334**. Screen **332** can be a small wire fabric, mesh-type screen that is shaped and configured to fit within the first end **315** of valve body **313**. Screen **332** is utilized to keep hard water lime particles and other detritus out of bypass valve **311** and to act as a seat for the over-travel spring (as explained above). Screen **332** is positioned inside valve body **313**, as shown in FIG. **25**, at the intersection of first inlet port **319** and first discharge port **321** so as to have its surface swept clean each time the hot water faucet is turned on. The retention pin **334** is to hold screen **332**, as well as the other components, in place inside valve body **313**. Retention pin **334** is installed in valve body **313** through first discharge port **321** so as to abut screen **332**, thereby eliminating the need for an extra external seal.

In an alternative embodiment, a snap-in cartridge check valve **336** is located in the second end **309** of valve body **313**, as shown in FIG. **25**, to prevent siphoning of cold water through the bypass valve **311** when only the hot water faucet is on, and at a high flow rate, prior to the hot water temperature rising. The preferred embodiment does not use the check valve because at very low flow rates the check valve will tend to chatter, which is a common problem with check valves.

In order to achieve the desired circulation flow, a single circulating pump **366** is utilized as part of a water circulating system **367**, as shown in FIG. **30**. Pump **366** can be a single, small pump of the type used in residential hot water space heating. In fact, a very low flow/low head pump is desirable, as a larger (i.e., higher head/higher flow) pump mounted at the typical domestic water heater **368** tends to be noisy. This annoying noise is often transmitted by the water pipes throughout the house. In addition, if the shower (as an example) is already in use when pump **366** turns on, whether the first start or a later cyclic turn-on, the sudden pressure boost in the hot water line from a larger pump can result in an uncomfortable and possibly near-scalding temperature rise in the water at the shower head or other fixture in use. The smaller boost of a "small" pump (i.e., one with a very steep flow-head curve) will result in only a very small and less noticeable increase in shower temperature. In the preferred embodiment, the single, small pump **366** needs to provide only a flow of approximately 0.3 gpm at 1.0 psi pressure. In accordance with pump affinity laws, such a "small" pump requires a very small impeller or low shaft speed. The inventors have found that use of a very small impeller or low shaft speed also precludes formation of an air bubble in the eye of the impeller, which bubble may be a major cause of noise. Such a small steep curve pump will, however, constitute a significant pressure drop in the hot water line when several fixture taps are opened simultaneously (such as a bathtub and the kitchen sink). To avoid reduced flow, a check valve **370** can be plumbed in parallel with pump **366** or incorporated within the pump housing, to pass a flow rate exceeding the pump's capacity around pump **366**. When pump **366** is powered and flow demand is low, check valve **370** prevents the boosted flow from re-circulating back to its own inlet. With check valve **370** plumbed around pump **366**, it is advantageous to place an orifice **372** in the pump discharge to provide a simple manner to achieve the desired very steep flow-head curve from available stock pump designs. A single pump **366** located at or near the water heater **368** in its discharge piping will boost the pressure in the hot water pipes somewhat above that in the cold water pipes (i.e., perhaps one to three feet of boost). With this arrangement only one pump **366** per plumbing system (i.e., per water heater) is required with any reasonable number of remote faucet sets (i.e., the typical number used in residences) equipped with bypass valves **311**. This is in contrast to those systems that require multiple pumps, such as a pump at each fixture where bypassing is desired.

If desired, pump **366** can operate twenty-four hours a day, with most of the time in the no flow mode. However, this is unnecessary and wasteful of electricity. Alternatively, pump **366** can have a timer **374** to turn on the pump **366** daily at one or more times during the day just before those occasions when hot water is usually needed the most (for instance for morning showers, evening cooking, etc.) and be set to operate continuously for the period during which hot water is usually desired. This still could be unnecessary and wasteful of electricity. Another alternative is to have the timer **374** cycle pump **366** on and off regularly during the period when hot water is in most demand. The "on" cycles should be of sufficient duration to bring hot water to all remote fixtures that are equipped with a bypass valve **311**, and the "off" period would be set to approximate the usual time it takes the water in the lines to cool-down to minimum acceptable temperature. Yet another alternative is to equip pump **366** with a normally closed flow switch **376** sized to detect significant flows only (i.e., those flows that are much larger than the bypass valve **311** flows), such as a shower flowing. For safety purposes, the use of such a switch **376** is basically required if a cyclic timer **374** is used. The switch can be wired in series with the pump motor. If the switch indicates an existing flow at the moment the timer calls for pump on, the open flow switch will prevent the motor from starting, thereby avoiding a sudden increase in water temperature at the fixture (i.e., a shower) being utilized. The use of such a switch accomplishes several useful objectives, including reducing electrical power usage and extending pump life if hot water is already flowing and there is no need for the pump to operate, avoiding a sudden temperature rise and the likelihood of scalding that could result from the pump boost if water is being drawn from a "mixing" valve (such as a shower or single handle faucet) and allowing use of a "large" pump (now that the danger of scalding is eliminated) with its desirable low pressure drop at high faucet flows, thereby eliminating the need for the parallel check valve **370** required with a "small" pump.

By using a time-of-day control timer **374**, pump **366** operates to maintain "instant hot water" only during periods of the day when it is commonly desired. During the off-cycle times, the plumbing system operates just as if the bypass valves **311** and pump **366** were not in place. This saves electrical power usage from pump operation and, more importantly, avoids the periodic introduction of hot water into relatively uninsulated pipes during the off-hours, thereby saving the cost of repeatedly reheating this water. The time-of-day control also avoids considerable wear and tear on pump **366** and the bypass valves **311**. Considerable additional benefits are gained by using a cyclic timer **374**, with or without the time-of-day control. In addition to saving more electricity, if a leaky bypass valve or one not having toggle action is used, there will be no circulating leakage while the pump is cycled off, even if the valve fails to shut off completely. Therefore, a simple (i.e., one not necessarily leak tight) valve may suffice in less demanding applications. Having the leakage reduced to just intermittent leakage will result in reduced warming of the cold water line and less reheating of "leaking" recirculated water. In addition, shut-off of a toggle action valve upon attainment of the desired temperature is enhanced by the differential pressure an operating pump provides. If pump **366** continues to run as the water at the bypass valve **311** cools down, the pump-produced differential pressure works against re-opening the valve. If pump **366** operates cyclically, powered only a little longer than necessary to get hot water to bypass valve **311**, it will be "off" before the valve **311** cools down. When the minimum temperature is reached, the thermal actuator **326** will retract, allowing the bias spring **328** to open the valve **311** without having to fight a pump-produced differential pressure. Bypass flow will begin with the next pump "on" cycle. An additional benefit to the use of either a time-of-day or cyclic timer **374** is that it improves the operating life of thermal actuator **326**. Because use of either timer **374** causes cyclic temperature changes in valve **311** (as opposed to maintaining an equilibrium setting wherein temperature is constant and the actuator barely moves), there is frequent, substantial motion of the piston **350** in thermal actuator **326**. This exercising of actuator **326** tends to prevent the build-up of hard water deposits and corrosion on the actuator piston **350** and poppet face, which deposits would render the valve **311** inoperable.

In the preferred embodiment, bypass valve **311** is manufactured from a one-piece molded valve body **313** that is configured as described above with fin guides **338**, internal shoulder **340**, passage **337**, retaining pin hole **344** and retaining slot **346** for ease of manufacture and reduced manufacturing costs. The bias spring **328**, wax cartridge actuating element **326** with its piston/poppet rod member **350**, the over-travel spring **330** and screen **332** are placed into the "hot" axial port (the first inlet port **319**) in that order. Screen **332** is pushed against the over-travel spring **330** compressing it, thereby making room for insertion of the retaining pin **334** through the retaining pin hole **344** at the "hot" radial port (the first discharge port **321**). The cartridge check valve **336**, if utilized, is inserted into the "cold" axial port (the second inlet port **323**) and snaps into place in retaining slot **346**.

Installation of the bypass valve **311** is also made easy by manufacturing the valve **311** in the configuration as set forth above. As discussed, valve body **313** is molded with four ports (designated as **319**, **321**, **323** and **325**) to allow installation with commonly used under-sink (as an example) vinyl hoses or flexible metal pipe, shown as **378** in FIG. **30**, having swivel ends and faucet washers. The inlet ports **319** and **323** on valve body **313** are formed with one-half inch straight pipe threads to allow the installer to remove the end of the wall shut off-to-faucet hoses (hot and cold) at the faucet **380** and connect those ends, which are commonly one-half inch straight pipe threads, to valve inlets **319** and **323**. The valve discharge ports **321** and **325** are likewise molded with one-half inch straight pipe threads to allow connection from them to the hot **382** and cold **384** inlets at faucet **380**. The threads on all four ports will seal only with hose washers and swivel nuts. Because the use of a plastic valve body **313** is envisioned, the inability to mount valve body **313** directly to "hard" plumbing with taper pipe threads insures that the body **313** will be connected only with flexible lines **378**, thereby precluding any plumbing loads that might overstress the non-metallic body. Because all current American faucets **380** are equipped with one-half inch straight pipe threads, the recommended procedure is to remove the pair of existing connection hoses **378** from the faucet **380** and connect these loose ends to the appropriate inlet ports **319** and **323** of valve body **313**. The angle stop valves at the wall may have any of several possible thread size connections, or may have permanently connected hoses or tubes. As a result, it is best not to disturb these wall connections, but instead use hoses **378** to connect from the angle stop to bypass valve **311**. A new set of hoses **378** with one-half inch straight pipe thread swivel nuts at both ends can then be connected from discharge ports **321** and **325** of valve body **313** to the appropriate hot **382** and cold **384** water connections on faucet **380**.

FIG. **31** illustrates another exemplary water distribution system **1012** utilizing a water control fixture **1010**. The water control fixture is illustrated as being a faucet, however, other water control fixtures may be adaptable to the thermal bypass valve features described herein (i.e., solenoid valve used on home laundry washing machines). The water distribution system **1012** typically comprises a supply of cold water **1014**, such as from a city main or water well, that supplies cold water directly to faucet **1010** through cold water line **1016** and water to hot water heater **1018** so that it may heat the water and supply hot water to faucet **1010** through hot water line **1020**. Cold water line **1016** connects to faucet **1010** through cold water inlet **1022** and hot water line **1020** connects to faucet **1010** through hot water inlet **1024**, as explained in more detail below.

An exemplary system **1012** utilizes a small circulating pump **1026** of the type used in residential hot water space heating. A very low flow and low head pump is desirable because a larger (i.e., higher head/higher flow) pump mounted at the typical domestic water heater **1018** tends to be noisy. This annoying noise is often transmitted by the water pipes throughout the house. In addition, if the shower (as an example) is already in use when pump **1026** turns on, whether the first start or a later cyclic turn-on, the sudden pressure boost in the hot water line **1020** from a larger pump can result in an uncomfortable and possibly near scalding temperature rise in the water at the shower head or other fixture in use. The smaller boost of a "small" pump (i.e., one with a very steep flow-head curve) will result in only a very small and less noticeable increase in shower temperature. In the preferred embodiment, the single, small pump **1026** needs to provide only a flow of approximately 0.3 gpm at 1.0 psi pressure. In accordance with pump affinity laws, such a "small" pump requires a very small impeller or low shaft speed. The inventors have found that use of a very small impeller or low shaft speed also precludes formation of an air bubble in the eye of the impeller, which bubble may be a major cause of noise. Such a small steep curve pump may, however, constitute a significant pressure drop in the hot water line **1020** when several fixture taps are opened simultaneously (such as a bathtub and the kitchen sink). To avoid reduced flow in those installations having a relatively low volume pump, a check valve **1028** can be plumbed in parallel with pump **1026** or incorporated within the pump housing, to pass a flow rate exceeding the pump's capacity around pump **1026**. When pump **1026** is powered and flow demand is low, check valve **1028** prevents the boosted flow from re-circulating back to its own inlet. With check valve **1028** plumbed around pump **1026**, it is advantageous to place an orifice **1030** in the pump discharge to provide a simple manner to achieve the desired very steep flow-head curve from available stock pump designs. A single pump **1026** located at or near the water heater **1018** in its discharge piping will boost the pressure in the hot water pipes somewhat above that in the cold water pipes (i.e., perhaps one to three feet of boost). With this arrangement only one pump **1026** per plumbing system (i.e., per water heater **1018**) is required with any reasonable number of remote faucets **1010** (i.e., the typical number used in residences) equipped with bypass valves. This is in contrast to those systems that require multiple pumps, such as a pump at each fixture where bypassing is desired.

If desired, pump **1026** can operate twenty-four hours a day, with most of the time in the no flow mode. However, this is unnecessary and wasteful of electricity. Alternatively, pump **1026** can have a timer **1032** to turn on the pump **1026** daily at one or more times during the day just before those occasions when hot water is usually needed the most (for instance for morning showers, evening cooking, etc.) and be set to operate continuously for the period during which hot water is usually desired. This still could be unnecessary and wasteful of electricity. Another alternative is to have the timer **1032** cycle pump **1026** on and off regularly during the period when hot water is in most demand. The "on" cycles should be of sufficient duration to bring hot water to all remote fixtures **1010** that are equipped with a bypass valve, and the "off" period would be set to approximate the usual time it takes the water in the lines to cool-down to minimum acceptable temperature. Yet another alternative is to equip pump **1026** with a normally closed flow switch **1034** sized to detect significant flows only (i.e., those flows that are much larger than the bypass valve flows), such as a shower flowing. For safety purposes, the use of such a switch **1034** is basically required if a cyclic timer **1032** is used. The switch **1034** can be wired in series with the motor in pump **1026**. If the switch **1034** indicates an existing flow at the moment the timer calls for pump **1026** to be on, the open flow switch **1034** will prevent the motor from starting, thereby avoiding a sudden increase in water temperature at the fixture **1010** (i.e., particularly if it is a shower) being utilized. The use of such switch **1034** accomplishes several useful objectives, including reducing electrical power usage and extending pump life if hot water is already flowing and there is no need for the pump to operate, avoiding a sudden temperature rise and the likelihood of scalding that could result from the pump boost if water is being drawn from a "mixing" valve (such as a shower or single handle faucet) and allowing use of a "large" pump (now that the danger of scalding is eliminated) with its desirable low pressure drop at high faucet flows, thereby eliminating the need for the parallel check valve **1028** required with a "small" pump.

By using a time-of-day control timer **1032**, pump **1026** operates to maintain "instant hot water" only during periods of the day when it is commonly desired. During the off-cycle times, the plumbing system **1012** operates just as if the faucet **1010** having bypass valves and pump **1026** were not in place. This saves electrical power usage from pump operation and, more importantly, avoids the periodic introduction of hot water into relatively un-insulated pipes during the off-hours, thereby saving the cost of repeatedly reheating this water. The time-of-day control also avoids considerable wear and tear on pump **1026** and the bypass valve in faucet **1010**. Considerable additional benefits are gained by using a cyclic timer **1032**, with or without the time-of-day control. In addition to saving more electricity, if a leaky bypass valve or one not having toggle action is used, there will be no circulating leakage while the pump **1026** is cycled off, even if the valve fails to shut off completely. Therefore, a simple (i.e., one not necessarily leak tight) valve may suffice in less demanding applications. Having the leakage reduced to just intermittent leakage will result in reduced warming of the cold water line **1016** and less reheating of "leaking" re-circulated water.

The bypass valve assemblies **1036** have a thermally sensitive actuating element **1038**, an example of which is shown in FIG. **32**, for thermostatically controlling bypass valve **1036**. Actuating element **1038** is preferably of the wax filled cartridge type, also referred to as wax motors, having an integral poppet rod member **1040**, as best shown in FIG. **32**. Rod member **1040** comprises poppet **1042** attached to piston **1044** with an intermediate flange **1046** thereon. The end of poppet **1042** is configured to seat directly against a valve seat or move a shuttle (i.e., spool or sleeve valves) so as to close a passage. These thermostatic control elements **1038** are well known in the art and are commercially available from several suppliers, such as Caltherm of Bloomfield Hills, Mich. The body **1048** of actuating element **1038** has a section **1050** of increased diameter, having a first side **1052** and second side **1054**, to seat against a shoulder or like element in a valve body. Piston **1044** of rod member **1040** interconnects poppet **1042** with actuator body **1048**. Actuating element **1038** operates in a conventional and well known manner. Briefly, actuating element **1038** comprises a blend of waxes or a mixture of wax(es) and metal powder (such as copper powder) enclosed in actuator body **1048** by means of a membrane made of elastomer or the like. Upon heating the wax or wax with copper powder mixture expands, thereby pushing piston **1044** and poppet **1042** of rod member **1040** in an outward direction. Upon cooling, the wax or wax/copper powder mixture contracts and rod member **1040** is pushed inward by a bias spring until flange **1046** contacts actuator body **1048** at actuator seat. Although other types of thermal actuators, such as bimetallic springs and memory alloys (i.e., Nitinol and the like) can be utilized, the wax filled cartridge type is preferred because the wax can be formulated to change from the solidus to the liquid state at a particular desired temperature. The rate of expansion with respect to temperature at this change of state is many times higher, resulting in almost snap action of the wax actuating element **1038**. The temperature set point is equal to the preset value, such as 97 degrees Fahrenheit, desired for the hot water. This is a "sudden" large physical motion over a small temperature change. As stated above, this movement is reacted by a bias spring that returns rod member **1040** as the temperature falls.

Because the bypass valve **1036** has little or no independent "toggle action," after a few cycles of opening and closing, the valve tends to reach an equilibrium with the plumbing system, whereby the bypass valve **1036** stays slightly cracked open, passing just enough hot water to maintain the temperature constantly at its setting. In particular plumbing systems and at certain ambient conditions, this flow is just under that required to maintain a spring loaded check valve cracked continuously open. In such a situation, the check valve chatters with an annoying buzzing sound. To avoid this occurrence, the spring may be removed from the check valve, leaving the poppet free floating. In the event that the hot water is turned full on at a time when the bypass valve **1036** is open, thereby lowering the pressure in the hot water line **1020**, and so inducing flow from the cold water line **1016** through the open bypass valve **1036** to the hot side, the free floating poppet will quickly close. There is no necessity for a spring to keep this check valve closed prior to the reversal in pressures.

Although not entirely demonstrated in early tests, it is believed that beneficial "toggle" action can be achieved with a bypass valve **1036** of very simple mechanical design. If the motion of the thermal actuator **1038** is made to lag behind the temperature change of the water surrounding it by placing suitable insulation around the actuator **1038** or by partially isolating it from the water, then instead of slowly closing only to reach equilibrium at a low flow without reaching shutoff, the water temperature will rise above the extending temperature of the insulated actuator **1038** as the valve approaches shutoff, and the piston **1044** will then continue to extend as the internal temperature of the actuator **1038** catches up to its higher surrounding temperature, closing the valve **1036** completely. It is also believed that an insulated actuator **1038** will be slow opening, its motion lagging behind the temperature of the surrounding cooling-off water from which it is insulated. When actuating element **1038** finally begins to open the valve **1036** and allow flow, the resulting rising temperature of the surrounding water will again, due to the insulation, not immediately affect it, allowing the bypass valve **1036** to stay open longer for a complete cycle of temperature rise. Such an "insulated" effect may also be accomplished by use of a wax mix that is inherently slower, such as one with less powdered copper or other thermally conductive filler. An actuator **1038** to be installed with insulation can be manufactured with a somewhat lower set point temperature to make up for the lag, allowing whatever valve **1036** closing temperature desired.

An additional benefit of utilizing pump **1026** in system **1012** is that shut-off of a toggle action valve upon attainment of the desired temperature is enhanced by the differential pressure an operating pump **1026** provides. If pump **1026** continues to run as the water at the faucet **1010** cools down, the pump-produced differential pressure works against re-opening a poppet type bypass valve **1036** in faucet **1010**. If pump **1026** operates cyclically, powered only a little longer than necessary to get hot water to faucet **1010**, it will be "off" before the water at valve **1036** cools down. When the minimum temperature is reached, the thermal actuator **1038** will retract, allowing the bias spring to open valve **1036** without having to fight a pump-produced differential pressure. Bypass flow will begin with the next pump "on" cycle. An additional benefit to the use of either a time-of-day or cyclic timer **1032** is that it improves the operating life of thermal actuator **1038**. Because use of either timer **1032** causes cyclic temperature changes in valve **1036** (as opposed to maintaining an equilibrium setting wherein temperature is constant and the actuator **1038** barely moves), there is frequent, substantial motion of the piston **1044** in thermal actuator **1038**. This exercising of actuator **1038** tends to prevent the build-up of hard water deposits and corrosion on the cylindrical surface of actuator piston **1044** and face of poppet **1042**, which deposits could render the valve **1036** inoperable.

Also inside valve **1036** can be an over-travel spring (not shown) disposed between the first side **1052** of the actuator body **1048** and a stop located inside valve **1036** to prevent damage to a fully restrained actuator **1038** if it were heated above the bypass valve's maximum operating temperature and to hold the actuator **1038** in place during operation without concern for normal tolerance. Use of an over-travel spring, which is not necessary for spool-type valves, allows movement of the actuator body **1048** away from the seated poppet **1042** in the event that temperature rises substantially after the poppet **1042** contacts its seat. Without this relief, the expanding wax could distort its copper can, destroying the calibrated set point. The over-travel spring also holds the bias spring, rod member **1040** and actuator body **1048** in place without the need to adjust for the stack-up of axial tolerances. Alternatively, actuator **1038** can be fixedly placed inside valve **1036** by various mechanisms known in the art, including adhesives and the like. Over-travel spring, if used, can be held in place by various internal configurations commonly known in the art, such as a molded seat.

As there are a great many configurations and brands of faucets **1010**, there are several different preferred designs of bypass valve **1036** placement and arrangement to accommodate these many faucet configurations. Various specific examples are set forth below. The following examples are representative of the types of uses to which the integral or in-faucet bypass valve **1036** is suitable. The examples are for illustrative purposes only and are not intended to restrict the components to particular uses, sizes or materials used in the examples.

For instance, there are several basic types of faucet assemblies, including those that have a single handle faucet assembly that mixes the hot and cold water and delivers a flow of water out the single spout based on the user's movement of the faucet's valve assembly. Another common type of faucet assembly is the dual handle, single spout faucet assembly that has separate handles for the hot and cold water. As with the single handle assembly, the hot and cold water are mixed prior to the spout based on the user's selection of the amount of flow of hot and/or cold water. A third, older arrangement is the use of completely separate faucets for hot and cold water. Although the different manufacturers of faucets may utilize different arrangements of valving components, different valving mechanisms and/or different valves to water supply line connections, the bypass valve system is adaptable to all such known configurations. As set forth below, the primary selection in the use of the bypass faucet assembly is whether to place the bypass valve in a stationary portion of the faucet, such as the hot water piping leading to the faucet or in a housing or block portion of the faucet, or to place the bypass valve in the moveable valving of the faucet. Selection of which location to place the bypass valve assembly will often be dictated by economics, preferences, limitations on the amount of space available, the current design of the faucet and/or the willingness to change.

EXAMPLE 1

Single Handle Faucets w/ Bypass Valve in Stationary Block

As is well known, single handle faucets, an example of which is shown as fixture body **1060**, faucet **1010** without its decorative covering, in FIGS. **33** and **34**, have both hot **1024** and cold **1022** water inlets connected to a housing or block **1062**. Various internal valving means, such as pivoting and rotating ball **1064**, selectively and adjustably control the volume and temperature of the flow of water by connecting the hot **1020** and cold **1016** lines, through hot and cold conduits **1066** and **1068** respectively (as shown in FIGS. **35** and **37**), to a single outlet spout **1070** through spout outlet **1072**. In such designs, the thermal bypass valve **1036** is preferably assembled into an easily replaceable cartridge **1074**, shown best in FIGS. **38**, **39** and **40**, that can be located within the hot water conduit **1066** of fixture body **1060** (if the design provides such access) or in an added cavity **1076** placed between and connected to the hot **1024** and cold **1022** inlets, as shown in FIG. **37**. In either case, the bypass valve **1036** senses and is controlled by the temperature of the "hot" water in the fixture body **1060**. When the "hot" water is cooled off due to long disuse, the bypass valve **1036** will open, providing a conduit between the hot **1024** and cold **1022** inlets. If the hot water line pump **1026** is then turned on, the boosted pressure in the hot water line **1020** will produce flow through the open bypass valve **1036**, bringing "hot" water to the fixture body **1060**. In the above-mentioned arrangements, the flow of water from both hot **1020** and cold **1016** lines remains unimpeded due to the previously mentioned internal valving arrangement of the fixture body **1060**. The flow from the hot line **1020** through the bypass valve cartridge **1074** to the cold line **1016** is provided through molded or cast passages or cross-drilled holes, discussed below.

The single handle faucet body **1060** with spherical ball valving means **1064**, shown in FIGS. **33** and **34**, is a good example of a faucet design that can be easily and economically re-designed to include a bypass valve cartridge **1074** in the stationary housing **1062**. Use of this approach requires al new fixture body **1060** to be installed, with a top-accessible, suitably sized cavity **1076** to hold the bypass cartridge **1074** and connect conduits **1066** and **1068** built into the fixture body **1060** to accommodate the bypassed flow from the hot **1020** to the cold **1016** lines. FIGS. **35** through **37** show a modified and lengthened version of a Delta housing **1062** that is used with the standard Delta faucet outer housing. The portion **1078** above line AA (i.e., to the left of AA in FIG. **36**) it is essentially an original Delta housing, with the addition of bore **1076**. Below AA (i.e., to the right of AA in FIG. **36**) is extension **1080**. In an exemplary use, these sections **1078** and **1080** would be made in a single, integral housing **1062**. Cavity **1076** and the drilled and plugged cross passages **1082** and **1084** are added, and the top bore **1086** is extended inward if and as much as is needed to accommodate any necessary devices, such as a ring or washer to hold cartridge assembly **1074** in place in cavity **1076**. Drilled passage **1082** connects the cold water supply to cavity **1076** near its top and drilled passage **1084** connects the hot water line **1020** to cavity **1076** near its bottom.

FIGS. **38** and **39** show the bypass valve cartridge **1074**, without its internal components, that is designed and configured to fit in cavity **1076**. FIG. **40** shows the components, including thermal actuator **1088**, assembled together as they would fit into cavity **1076**. The thermal actuator **1088** is a modified version of the actuator **1038** shown in FIG. **32**. Water from hot water line **1020** is carried through drilled hole **1084** to the lower end of cavity **1076** and flows up around and through the cartridge **1074** to and through the open valve seat **1090** (poppet **1042** is shown closed into against O-ring **1092** forming seat **1090** in FIG. **40**) into the check valve chamber **1094** housing check valve **1096** and out through the cross drilled hole **1098** into an annulus **1100** on the cartridge **1074**.

From annulus **1100**, between O-rings **1102** and **1104**, the water flows through drilled passage **1082** to the cold water supply. When sufficient water has flowed through the bypass valve **1036** to exhaust the cooled-off water in the hot water supply line **1020** and bring hot water to the bypass valve **1036**, the thermal actuator **1088** will cause piston **1044** to extend, forcing poppet **1042** into seat **1090** to close off the flow. The seat O-ring **1092** is held in place by spring **1106**, which doubles as the bias or poppet return spring. In the preferred embodiment, thermal actuator **1088** is held in place by a snap fit into the split cartridge **1074**, which is designed to be easily moldable. The check valve **1096** is included to prevent flow of cold water into the hot side when the hot water is turned full on in the system, or the equivalent usage of hot water, resulting in a lowered pressure on the hot side. The cartridge **1074** can be held down in cavity **1076** by a brass ring, or the like, which is in turn held down by the screw-on bonnet, which also captures the existing ball valving assembly **1064**.

Another example of a single handle water control fixture is shown as **1110** in FIG. **41**. This fixture **1110** is a modified Moen shower valve that comprises a rear housing **1112** attached to the rear **1114** of Moen housing **1116**. Housing **1116** has a hot water inlet port **1118** and a cold water inlet port **1120** for receiving hot and cold water, respectively, from the hot **1020** and cold **1016** water lines and a valve cavity **1122** for receiving the operating valve (not shown) through valve opening **1124**. The operating valve controls the flow of hot and cold water out of the spout associated with valve **1110**. Rear housing **1112** has a cavity **1126** configured to hold cartridge **1127** and hot **1128** and cold **1130** water channels to allow passage of water around valve cavity **1126** until the hot water reaches the desired temperature to cause actuator **1038** to push piston **1044** rearward until poppet **1042** engages valve seat **1090** to shut-off hot water flow through hot water channel **1128**, thereby ending the diversion of "hot" water to the cold water channel **1130**. Elastomeric washer shaped diaphragm **1125** acts as a check valve to prevent back flow of cold to hot when hot water line pressure is reduced. Conical washer shaped screens **1129** filers detritus and other trash from passing water. Screens **1129** are self-cleaning due to the high water velocities encountered when the shower valve is running hot water.

EXAMPLE 2

Single Handle Faucets w/Bypass Valve in Moveable Valving

This family of valves may utilize either a moveable perforated hollow spherical ball **1064**, as shown in FIGS. **33** and **34**, or an internally moveable valve cartridge, that have a common internal flow area to selectively and adjustably connect the hot **1020** and cold **1016** lines to the discharge spout **1070**. It is possible to place the same thermal valve system **1036** (in a more compact form) inside of a replacement one inch diameter ball **1134** for the moveable ball type or inside the replaceable faucet cartridges with internally moveable valving parts.

The previous simple hollow sphere, now **1134** (shown in FIGS. **42**, **43** and **44**), is structurally divided into two separate compartments inside ball body **1135**, an outer annular compartment **1136**, coaxial with the centerline of the actuating stem **1138**, and a cylindrical inner compartment **1140**, also coaxial with the centerline of the actuating stem **1138**. Passage **1162**, connected to annulus **1159**, and passage **1164**, connected to central bore **1157**, are separated by the valving action of the bypass valve **1036** installed in compartment **1140**. Ball **1134** is made in two parts, an upper half **1142** and a lower half **1144** (relative to the stem **1138** which normally extends upward), which screw together for convenience in development work. The thermal actuator **1088** is enclosed in the inner compartment **1140** is the same as the actuator discussed above, but with a shortened guide length and a cut-off piston **1044** with no poppet. The radially squeezed O-ring **1146** seals the two halves **1142** and **1144** of ball **1134**, and is held in place by the spring **1148**, which also functions as the bias or return spring. The piston **1044** is cut off short to conserve space, and bears on the upper end of drilled hole **1150**. Unlike the above-mentioned actuators, this piston **1044** remains stationary and it's the thermal actuator body **1048** that moves against spring **1148** to push the elastomer poppet disc **1152**, which doubles as a check valve, against the stationary seat **1154** as the valve **1134** heats up.

The two inlet ports on ball body **1135**, shown as **1156** for the hot water inlet port and **1158** for the cold water inlet port on FIGS. **43** and **44**, selectively and adjustably communicate with the hot **1020** and cold **1016** lines. The ball discharge port **1160** communicates in all ball positions with the faucet spout to discharge water from faucet **1010**. Ports **1156**, **1158** and **1160** are located in exactly the same locations on the ball body **1135** as the prior art ball **1064** previously. However all three ports are connected within the ball to annular compartment **1136** instead of to the entire inner volume of the hollow prior art ball **1064**. In the shut-off mode, the hot and cold inlet ball ports **1156** and **1158**, respectively, of ball **1134** are shifted away from the hot **1020** and cold **1016** lines, as with prior art ball **1064**. However, ball **1134** includes two added small ports **1162** and **1164** to the unperforated spherical surface that previously blocked off the hot **1020** and cold **1016** lines. Ports **1162** and **1164** connect the hot **1020** and cold **1016** lines to the central bore **1157** and annulus **1159**, which are valved by action of poppet disc **1152**. When the ball **1134** is cold due to a cooled-off hot water line **1020**, the bypass valve **1036** opens, allowing communication between the annulus **1159** and central bore **1157**. With the faucet **1010** in the shut-off position, the two added ports **1162** and **1164** thus allow communication between a cooled-off "hot" line **1020** and the cold line **1016**, and consequently a flow of water from the boosted "hot" line **1020** to the cold line **1016**. Positioning slot **1165** in ball **1134**, also in ball **1064**, is used to position ball **1134** in the faucet. The bypass action described above is accomplished without change to any part of the faucet **1010** except the replaceable valving ball **1134**. It is thus very easy to retrofit an existing faucet to the bypass function by simply replacing the existing "standard" design hollow ball **1064** with the new ball **1134**, as described.

There are several major advantages to this arrangement. These advantages include: (1) the complete ball **1134** is easily replaced to fix a malfunctioning bypass valve **1036**; (2) for retrofit, the original ball **1064** can be removed and replaced with the new valve-in-ball **1134**. No other changes need be made to the existing faucet **1010** (however, a booster pump **1026** located near the hot water heater **18** in the hot water line **1020** does of course need to be installed). This is particularly advantageous where it would be very difficult or impractical to replace an existing complete faucet valve, such as a shower valve installed behind a tiled wall.

While the hollow ball **1064** of the Delta faucet (and other clone faucets) provides an adequate space in a convenient location for installation of the bypass valve **1036**, a miniaturized version of the bypass valve **1036** can also be fitted into the replaceable cylindrical valving cartridges of other brands of single handle faucets with an action characterized by oscillating movement about a vertical centerline to adjust water temperature. Such a valving action to control mixing is commonly used in Price-Pfister, Sterling, American Standard, Moen, and Kohler faucets, among others. These faucets use a push-pull or tipping lever action to operate the on-off function within the same (usually) cylindrical cartridge. On some configurations, it is likely that space would have to be made by lengthening these cylindrical faucet cartridges, which would in turn call for a compensating change to the faucet central housing.

FIG. **45** shows a modification of a widely used Moen designed faucet **1200** as an example of a fixture that utilizes a replaceable cylindrical valving cartridge **1202**. The modifications to the faucet **1200** include adding a hot water bypass valve **1036** within the moving valving spool **1204** of the Moen design. This valve design is of the type wherein on/off and metering adjustment is accomplished by axial motion of the center spool **1204** (off is all the way inward). Hot/cold mixing adjustment is by angular positioning of the center spool **1204** when it is; wholly or partially pulled out to the on position. The faucet **1200** typically has a brass housing **1206** connected to the cold water inlet **1208** and hot water inlet **1210**. A spout connection **1212** allows water to exit the fixture **1200**. FIG. **45** shows the spool **1204** in its outward or "full on" position (slot **1214** axially aligns with spout port **1212** and slot **1216** axially aligns with cold **1208** and hot **1210** inlet ports) and angularly rotated so that the hot port **1210** is open to slot **1216** but cold port **1208** is blocked off.

In the position shown in FIG. **45**, hot water from port **1210** can enter through slot **1216** to the interior of tubular spool **1204** and proceed through hollow shuttle **1218** to slot **1214** and exit out spout port **1212**. Arrows **1220** indicate the length of travel of the spool **1204**. Tubular member **1222** is a stationary (preexisting) sleeve incorporated within the housing **1206** to allow placement and retention of the three elastomer seals **1224** to bear against and dynamically seal with spool **1204**. It also provides a vent path around its exterior for the space at the "bottom" of the valve **1200** to allow axial (piston) motion of spool **1204** without encountering hydraulic lock. Spool **1204** is shown in a simplified one-piece configuration for clarity.

The bypass valve **1036** components (consisting of bias spring **1226**, shuttle **1218**, actuator piston **1228** and actuator **1230**) are enclosed within the tubular portion of spool **1204**. Shuttle **1218** is located (floats) between bias spring **1226** and actuator **1230**. Shuttle **1218** has a central cruciform shaped member with an integral elastomer sleeve **1232** attached to the four legs of the cruciform. Four axial passages within the sleeve **1232** and around the cruciform are thus provided. This elastomer sleeve **1232** is in contact with and seals against the inner surface of tubular spool **1204**. When thermal actuator **1230** is heated to its actuation temperature, it "suddenly" extends piston **1228** outward, moving shuttle **1218** (to the left in FIG. **45**) against bias spring **1226**.

Two bleed holes **1234** and **1236** are so located through the wall of tubular spool **1204** as to line up with hot water inlet **1210** and cold water inlet **1208**, respectively, when the manually operated spool **1204** is pushed all the way into housing **1206** (the off position). Further, bleed hole **1236** is axially located slightly closer to the bias spring end of spool **1204**. O-rings **1238** seal spool **1204** and retaining clip **1240** holds sleeve **1222** within housing **1206**.

In FIG. **45**, the bypass valve **1036** components are shown in their "cold" positions. Hot bleed hole **1234** is covered by the end of the elastomer sleeve **1232** on shuttle **1218**, but cold bleed hole **1236** is uncovered. With spool **1204** pushed all the way in (off position) bleed hole **1234** communicates with hot water inlet **1210** and boosted hot water pressure communicates through hot bleed hole **1234**, this pressure deflects elastomer sleeve **1232** inward locally to allow flow from the boosted hot water line **1020** (presumably cooled off from a period of disuse) into the interior of tubular spool **1204** and out through uncovered cold bleed hole **1236**, which by virtue of the spool **1204** being in the off position is in communication with cold water inlet **1208**. A bypass of cooled off water from the hot water line **1020** to the cold water line **1016** is thus accomplished.

When sufficient cooled off water has passed through the valve **1200** to bring "hot" water to and through the valve **1200**, actuator **1230** will be warmed to its actuation temperature and will expand, forcing shuttle **1218** against bias spring **1226**. This axial movement will result in elastomer sleeve **1232** covering cold bleed hole **1236**. Boosted hot water pressure internal to sleeve **1232** will hold sleeve **1232** outward against the inner wall of tubular spool **1204**, effectively sealing bleed hole **1236**, and stopping the bypass flow until the valve cools down, causing bias spring **1226** to force shuttle **1218** back against piston **1010** into contracting actuator **1230**, again opening cold bleed hole **1236**.

The elastomer sleeve **1232** has a second function, that of acting as a check valve. When any faucet in the plumbing system is opened, the resulting flow may induce a substantial pressure drop in the associated plumbing line (either hot **1020** or cold **1016**, depending on which faucet was opened). If a bypass valve **1036** is open at such a time, such a pressure difference may cause sufficient water may leak through as to constitute a nuisance. If the lowered pressure is on the hot water line **1020**, no "leak" will occur as the higher pressure of the cold water inside the sleeve **1232** will hold it against the inner wall of tubular spool **1204** in the vicinity of hot bleed hole **1234**, effecting a seal. If the lowered pressure is on the cold side, the valve **1200** will allow cooled off water from the hot water line **1020** to bypass into the cold water line until warm water arrives at the valve **1200**, at which time the shuttle **1218** will shift and cut off the bypass.

EXAMPLE 3

Dual Handle, Single Spout Faucets

Although two handle, single spout faucets might have been expected to fade out of demand in favor of the more convenient single handle faucets, the two handle faucets (shown as **1010** in FIG. **31**) seem more amenable to elegant cosmetic design than their single handle cousins, which have an inherently more utilitarian look. Apparently for this reason, most double handle faucets on display are for lavatory use. The same requirements for ease of maintenance by allowing access to the bypass valve **1036** from the top apply to this faucet type. It is convenient that the prior art faucet design utilizing a rotating threaded stem with a faucet washer and a hard seat has become a thing of the past, as the newer designs with replaceable cartridges are more adaptable to this modification.

Most modern two handle faucets utilize a cartridge design in a pair of valve member **1166**, shown in FIG. **46**, wherein the valving function is accomplished within the cartridge that is positioned inside the housing section **1168** of valve member **1166**. This allows complete re-conditioning of the faucet by simply replacing a single assembly on each side. These cartridges are accessible in the housing section **1168** from the top by removing the faucet handles and bonnets that attach to the upper threaded portion **1170**. The cartridge assembly then simply lifts out, exposing its open cavity inside housing section **1168**, with a side port **1172** leading to confluence with the like port from the other side of the faucet, which confluence flows on through the single spout of such faucets. Below the mentioned cavity for the faucet valving cartridge there is an open one-half inch (typically) threaded pipe **1174** for the hot or cold conduit into the faucet. This externally threaded pipe is substantially longer than needed for valving or connection purposes to allow for overly thick lavatory counters and to get the lower end of these threaded pipes far enough down behind the sink for reasonable access by the installer. This "extra" space on the hot water side is a top accessible, hydraulically appropriate place to locate a thermal valve cartridge similar to the type described for inclusion in or adjacent to the hot water conduit in the central housing **1062** of a single handle faucet. Side port **1175** is added to housing section **1168** and a line is run to a like port on the other, opposing faucet. Addition of a thermal bypass valve **1036** requires additional machining and the addition of a bypass line connecting the hot and cold lines. An existing two handle single spout valve thus could not be retrofitted, but modifications to the design are relatively minor and the existing replaceable valve cartridge would fit the new design.

The major difference of concern in this matter between single handle single spout and two handle single spout faucet designs is that in the single handle central block, it is possible to create the connecting passages (bypass) by simply drilling cross holes, as discussed above. With two separate hot and cold faucet valves located four inches apart, some kind of cross conduit for the bypass must be added. There seem to be two approaches to directing the water from the hot and cold faucets to a confluence and out to the single spout. American-Standard, Oasis, La Bella and some Price-Pfisters use a large brass casting that includes the spout, both hot and cold faucet housings, and a cored cast passage connecting all of this together. Adding a thermal bypass valve **1036** to such a two handle faucet set would require the addition of an additional cored cast passage to accomplish the bypass function between hot and cold lines. Delta, Moen, Kohler, and some Price Pfister two handle single spout valves use brazed-in copper tube manifolds instead of cored cast passages. These would require the addition of a tubular cross passage brazed in. The Delta two handle single spout valve has a somewhat different valving action which makes it much more difficult to fit in a thermal valve cartridge. This new passage (cored or brazed tubular) needs to connect to the vertical hot and cold "pipe" members below their existing side port to the spout. These faucet sets generally do not have sufficient vertical space under the polished bezel to accommodate the extra passage. This will require addition of some vertical length to the skirt of the valve bezel.

FIG. **47** shows a modified "hot" side of a Kohler two handle faucet **1176**, with the housing shown as **1178**. The housing **1178** is identical to the standard existing Kohler housing **1178** above (to the right of) line M. The housing **1178** must be bored out in several steps to accommodate the new thermal valve cartridge **1180**, which can be a molded plastic cartridge identical in function to that already described for the center block of the Delta single handle valve. It varies from the previously described cartridge in the configuration of the passage to bring the hot water past the thermal valve **1036** to the faucet, and the configuration of the snap fit for the thermal actuator **1088**. It also has an upper extension **1182** with a through hole **1184**. The extension **1182** fits into a recess in the bottom of the existing Kohler faucet cartridge and the through hole **1184** is for engagement of a hook to allow removal of the thermal valve cartridge **1180** for replacement of the thermal bypass valve **1036**.

The operation of the bypass valve **1036** inside of faucet **1010** is summarized on the chart shown as FIG. **22** which indicates the results of the twenty combinations of conditions (pump on/pump off; hot water line hot/hot water line cooled off; hot faucet on, or off, or between; cold faucet on or off, or between) that are applicable to the operation of valve **1036**. The operating modes IVB, IVC, IVD, IIIB, & IIID are summarized detailed in the immediately following text. The operation of the remaining fifteen modes are relatively more obvious, and may be understood from the abbreviated indications in the outline summarizing FIG. **22**. Starting with the set "off" hours (normal sleeping time, and daytime when no one is usually at home) pump **1026** will not be powered. Everything will be just as if there were no pump **1026** and no bypass valve **1036** installed in faucet **1010** (i.e., both the cold and hot water lines will be at the same city water pressure). The hot water line **1020** and bypass valve **1036** will have cooled off during the long interim since the last use of hot water. The reduced temperature in the valve results in "retraction" of rod member **1040** of the thermally sensitive actuator **1088**. The force of bias spring **1106** pushing against flange **1046** on rod member **1040** will push it back away from valve seat **1090**, opening valve **1036** for recirculation. Although the thermal actuating element **1088** is open, with pump **1026** not running, no circulation flow results, as the hot **1020** and cold **1016** water piping systems are at the same pressure. This is the mode indicated as IVB in the outline on FIG. **22**. If the cold water valve at faucet **1010** is opened with the thermal element **1088** open as in mode IVB above, pressure in the line **1016** to the cold water side of faucet **1010** will drop below the pressure in the hot water line **1020**. This differential pressure will siphon tepid water away from the hot side to the cold side, which is the mode indicated as IVD in the outline on FIG. **22**. The recirculation of the "hot" water will end when the tepid water is exhausted from the hot water line **1020** and the rising temperature of the incoming "hot" water causes the thermal element **1088** to close.

If the hot water valve is turned on with the thermal element **1088** open as in mode IVB above, pressure in the line **1020** to the hot water side of faucet **1010** will drop below the pressure in the cold water line **1016**. This differential pressure, higher on the cold side, will load check valve **1096** in the "closed" direction allowing no cross flow. This is mode IVC in the outline on FIG. **22**. In this mode, with the hot water line **1020** cooled and the pump off, a good deal of cooled-off water will have to be run oust as if valve **1036** were not installed), to get hot water, at which time the thermal element **1088** will close without effect, and without notice by the user. With the thermal element **1088** open and the hot water line **1020** cooled-off as in mode IVB above, at the preset time of day (or when the cyclic timer trips the next "on" cycle) the pump **1026** turns on, pressurizing the water in the hot side of faucet **1010**. Pump pressure on the hot side of faucet **1010** results in flow through the open thermal element **1088**, thereby pressurizing and deflecting the check valve **1096** poppet away from its seat to an open position. Cooled-off water at the boosted pressure will thus circulate from the hot line **1020** through the thermal element **1088** and check valve **1096** to the lower pressure cold line **1016** and back to water heater **1018**. This is the primary "working mode" of the bypass valve **1036** and is the mode indicated as IIIB in the outline on FIG. **22**. If the cold water valve is turned on during the conditions indicated in mode IIIB above (i.e., pump **1026** operating, hot line **1020** cooled off, the hot valve at faucet **1010** off) and while the desired recirculation is occurring, mode IIID will occur. A pressure drop in the cold water line **1016** due to cold water flow creates a pressure differential across valve **1036** in addition to the differential created by pump **1026**. This allows tepid water to more rapidly bypass to the cold water inlet **1022** at faucet **1010**. When the tepid water is exhausted from the hot water line **1020**, thermal element **1088** will close, ending recirculation.

FIG. **48** illustrates another exemplary water distribution system **2018** utilizing a water control valve, which is illustrated in FIG. **48** as a tub/shower valve **2010**, separate service valves **2012** and a combined service valve **2014**. However, other water control valves may be adaptable to a bypass valve **2016**, including a thermostatically controlled bypass valve or other types of thermal actuators **2054**, such as bimetallic springs and memory alloys (i.e., Nitinol and the like), as described herein (i.e., valves used on washing machines, dishwashers and other fixtures). The bypass valve **2016** that is attached to or included with the water control valves can be one of many different types of available bypass valves, including thermostatically controlled bypass valves, electric solenoid controlled bypass valves, needle-type bypass valves as described in the above-referenced Blumenauer patent or mechanical push button bypass valves such as sold by Laing and others. The water control valves are adaptable for use with the various types of bypass valves by being attached, adjacent or included with the water control valve, as described in more detail below.

A typical water distribution system **2018** utilizing a tub/shower water control valve **2010**. The water distribution system **2018** typically includes a supply of cold water **2020**, such as from a city main or water well, that supplies cold water directly to water control valve **2010** through cold water line **2022** and water to hot water heater **2024** so that it may heat the water and supply hot water to water control valve **2010** through hot water line **2026**. Cold water line **2022** connects to water control valve **2010** at cold water inlet **2028** and hot water line **2026** connects to water control valve **2010** at hot water inlet **2030**, as explained in more detail below. In an exemplary embodiment, the system **2018** utilizes a small circulating pump **2032** of the type used in residential hot water space heating. A very low flow and low head pump **2032** is desirable because a larger (i.e., higher head/higher flow) pump mounted at the typical domestic water heater **2024** tends to be noisy. This annoying noise is often transmitted by the water pipes throughout the house. In addition, if the shower system **2034** (as an example) is already in use when pump **2032** turns on, whether the first start or a later cyclic turn-on, the sudden pressure boost in the hot water line **2026** from a larger pump can result in an uncomfortable and possibly near-scalding temperature rise in the water at the shower head or other fixture in use. The smaller boost of a "small" pump (i.e., one with a very steep flow-head curve) will result in only a very small and less noticeable increase in shower temperature.

In the preferred embodiment, the single, small pump **2032** needs to provide only a flow of approximately 0.3 gpm at 1.0 psi pressure. In accordance with pump affinity laws, such a "small" pump requires a very small impeller or low shaft speed. The inventors have found that use of a very small impeller or low shaft speed also precludes formation of an air bubble in the eye of the impeller, which bubble may be a major cause of noise. Such a small steep curve pump may, however, constitute a significant pressure drop in the hot water line **2026** when several fixture taps are opened simultaneously (such as a bathtub and the kitchen sink). To avoid reduced flow in those installations having a relatively low volume pump, a check valve **2036** can be plumbed in parallel with pump **2032** or incorporated within the pump housing, to pass a flow rate exceeding the pump's capacity around pump **2032**. When pump **2032** is powered and flow demand is low, check valve **2036** prevents the boosted flow from re-circulating back to its own inlet. With check valve **2036** plumbed around pump **2032**, it is advantageous to place an orifice **2038** in the pump discharge to provide a simple manner to achieve the desired very steep flow-head curve from available stock pump designs. A single pump **2032** located at or near water heater **2024** in its discharge piping will boost the pressure in the hot water pipes somewhat above that in the cold water pipes (i.e., perhaps one to three feet of boost). With this arrangement only one pump **2032** per plumbing system (i.e., per water heater **2024**) is required with any reasonable number, such as the typical number used in residences, of remote water control valves (i.e., tub/shower valve **2010** or service valves **2012** and **2014**), equipped with bypass valves. This is in contrast to those systems that require multiple pumps **2032**, such as a pump **2032** at each fixture where bypassing is desired.

If desired, pump **2032** can operate twenty-four hours a day, with most of the time in the no flow mode. However, this is unnecessary and wasteful of electricity. Alternatively, and preferably, pump **2032** can have a timer **2040** to turn pump **2032** on daily at one or more times during the day just before those times when hot water is usually needed the most (for instance for morning showers, evening cooking, etc.) and be set to operate continuously for the period during which hot water is usually desired. This still could be unnecessary and wasteful of electricity. Another alternative is to have the timer **2040** cycle pump **2032** on and off regularly during the period when hot water is in most demand. The "on" cycles should be of sufficient duration to bring hot water to all remote fixtures that have water control valves (such as valves **2010**, **2012** and **2014**) equipped with a bypass valve, and the "off" period would be set to approximate the usual time it takes the water in the lines to cool-down to minimum acceptable temperature. Yet another alternative is to equip pump **2032** with a normally closed flow switch **2042** sized to detect significant flows only (i.e., those flows that are much larger than the bypass flows), such as water flow during use of shower system **2034**. For safety purposes, the use of such flow switch **2042** is basically required if a cyclic timer **2040** is used. The switch **2042** can be wired in series with the motor in pump **2032**. If switch **2042** indicates an existing flow at the moment timer **2040** calls for pump **2032** to be activated, open flow switch **2042** will prevent the motor from starting, thereby avoiding a sudden increase in water temperature at the fixture (i.e., particularly if it is shower system **2034**) being utilized. The use of switch **2042** accomplishes several useful objectives, including reducing electrical power usage and extending pump **2032** life if hot water is already flowing and there is no need for pump **2032** to operate, avoiding a sudden temperature rise and the likelihood of scalding that could result from the pump boost if water is being drawn from a "mixing" valve (such as tub/shower valve **2010** shown in FIG. **48** or a single handle faucet) and allowing use of a "large" pump **2032** (now that the danger of scalding is eliminated) with its desirable low pressure drop at high flows, thereby eliminating the need for the parallel check valve **2036** required with a "small" pump **2032**.

By using a time-of-day control timer **2040**, pump **2032** operates to maintain "instant hot water" only during periods of the day when it is commonly desired. During the off-cycle times, the plumbing system **2018** operates just as if the fixture having bypass valve **2016** and pump **2032** were not in place. This saves electrical power usage from operation of pump **2032** and, more importantly, avoids the periodic introduction of hot water into relatively un-insulated pipes during the off-hours, thereby saving the cost of repeatedly reheating this water. The time-of-day control also avoids considerable wear and tear on pump **2032** and bypass valve **2016**. Considerable additional benefits are gained by using a cyclic timer **2040**, with or without the time-of-day control. In addition to saving more electricity, if a leaky bypass valve **2016** (i.e., leaks hot water to cold water line **2022**) or one not having toggle action is used, there will be no circulating leakage while the pump **2032** is cycled off, even if bypass valve **2016** fails to shut off completely. Therefore, a simple (i.e., not necessarily leak tight) bypass valve **2016** may suffice in less demanding applications. Reducing leakage to intermittent leakage results in reduced warming of the water in cold water line **2022** and less reheating of "leaking" re-circulated water.

As described above, water control valves **2010**, **2012** and **2014** can utilize various types of bypass valves **2016** to accomplish the objective of bypassing cold or tepid water around the fixture associated with water control valves **2010**, **2012** and **2014** which are adaptable for use with bypass valve **2016**. The preferred bypass valve **2016** is the thermostatically controlled type, an example of which is shown in FIG. **49** and described below, due to its ability to automatically sense and respond to the temperature of the water in hot water line **2026** at water control valve **2010**, **2012** or **2014**. Unlike the electrical solenoid type of bypass valve or the manually operated type of bypass valve, a thermostatically controlled bypass valve does not require any external operational input to activate in order to bypass cold or tepid water in hot water line **2026** so as to maintain hot water at hot water inlet **2030** of water control valves **2010**, **2012** or **2014**.

As best shown in FIGS. **49** through **51**, the preferred bypass valve **2016** is thermostatically controlled bypass valve **2016** configured for use with water control valves **2010**, **2012** and **2014** including a generally tubular valve body **2044** having bypass valve inlet **2046**, bypass valve outlet **2048** and a separating wall **2050** disposed therebetween. As described in more detail below, bypass inlet **2046** connects to hot water inlet **2030** and bypass outlet **2048** connects to cold water inlet **2028** of water control valves **2010**, **2012** and **2014**, either directly or indirectly. Bypass valve passageway **2052** in separating wall **2050** interconnects inlet **2046** and outlet **2048** to allow fluid to flow therethrough when bypass valve **2016** is bypassing cold or tepid water. As best shown in FIG. **49** and discussed in more detail below, valve body **2044** houses a thermally sensitive actuating element **2054**, bias spring **2056**, an over-travel spring **2058**, retaining mechanism **2062** (such as a retaining ring, clip, pin or other like device) and check valve **2064**. Valve body **2044** can most economically and effectively be manufactured out of a molded plastic material, such as Ryton®, a polyphenylene sulphide resin available from Phillips Chemical, or a variety of composites. In general, molded plastic materials are preferred due to their relatively high strength and chemical/corrosion resistant characteristics while providing the ability to manufacture the valve body **2044** utilizing injection molding processes with the design based on the configuration described herein without the need for expensive casting or machining. Alternatively, valve body **2044** can be manufactured from various plastics, reinforced plastics or metals that are suitable for "soft" plumbing loads and resistant to hot chlorinated water under pressure. As shown in FIG. **50**, inlet **2046** of valve body **2044** can be molded with a set of axially oriented fin guides **2066** having ends that form an internal shoulder **2068** inside valve body **2044** for fixedly receiving and positioning one end of thermal actuating element **2054** and bias spring **2056**, and retainer interruption **2072** for receiving retaining mechanism **2062**. Preferably, retaining mechanism **2062** is a retaining ring and retainer interruption **2072** is configured such that when retaining mechanism **2062** is inserted into valve body **2044** it will be engagedly received by retainer interruption **2072**. Bypass valve outlet **2048** can be molded with retaining slot **2074** for engagement with the snap-in check valve **2064**. In the preferred embodiment, valve body **2044** is designed so the components can fit through inlet **2046** and outlet **2048**, which will typically be one-half inch diameter. In this manner, a one piece bypass valve **2016** results with no intermediate or additional joints required for installation.

For ease of installation of the bypass valve **2016** by the user, both inlet **2046** and outlet **2048** on valve body **2044** can have one-half inch straight pipe threads for use with the swivel nuts that are commonly found on standard connection hoses that fit the typical residential fixture. The swivel nuts on the connection hoses seal with hose washers against the ends of inlet **2046** and outlet **2048**, as opposed to common pipe fittings that seal at the tapered threads. Inlet **2046** and outlet **2048** can be marked "hot" and "cold", respectively, to provide visual indicators for the do-it-yourself installer so as to avoid undue confusion. Alternatively, as explained below, bypass valve **2016** can be made with integral connections at inlet **2046** and outlet **2048** for connection to water control valve **2010**, **2012** or **2014**, thereby avoiding the need for extra connections.

An example of a thermally sensitive actuating element **2054** for use with the preferred thermostatically controlled bypass valve **2016** is shown in FIG. **51**. Another example of a thermally sensitive actuating element **2054'** for use with the thermostatically controlled bypass valve **2016** is shown in FIG. **51**A. Actuating element **2054** is preferably of the wax filled cartridge type, also referred to as wax motors, having an integral poppet rod member **2076** comprising poppet **2078** attached to piston **2080** with an intermediate flange **2082** thereon. The end of poppet **2078** is configured to seat directly against valve seat **2070** or move a shuttle (i.e., spool or sleeve valves) so as to close passage **2052**. These thermostatic control actuating elements **2054** are well known in the art and are commercially available from several suppliers, such as Caltherm of Bloomfield Hills, Mich. The body **2084** of actuating element **2054** has a section **2086** of increased diameter, having a first side **2088** and second side **2090**, to seat against shoulder **2068** or like element in valve body **2044**. Piston **2080** of rod member **2076** interconnects poppet **2078** with actuator body **2084**. Actuating element **2054** operates in a conventional and well known manner. Briefly, actuating element **2054** comprises a blend of waxes or a mixture of wax(es) and metal powder (such as copper powder) enclosed in actuator body **2084** by means of a membrane made of elastomer or the like. Upon heating the wax or wax with copper powder mixture expands, thereby pushing piston **2080** and poppet **2078** of rod member **2076** in an outward direction. Upon cooling, the wax or wax/copper powder mixture contracts and rod member **2076** is pushed inward by bias spring **2056** until flange **2082** contacts actuator body **2054** at actuator seat **2092**. Although other types of thermal actuators, such as bi-metallic springs (shown in FIG. **51**A) and memory alloys (i.e., Nitinol and the like) can be utilized, the wax filled cartridge type is preferred because the wax can be formulated to change from the solid to the liquid state at a particular desired temperature. The rate of expansion with respect to temperature at this change of state is many times higher, resulting in almost snap action of the wax actuating element **2054**. The temperature set point is equal to the preset value, such as 97 degrees Fahrenheit, desired for the hot water. This is a "sudden" large physical motion over a small temperature change. As stated above, this movement is reacted by bias spring **2056** that returns rod member **2076** as the temperature falls.

Because bypass valve **2016** has little or no independent “toggle action,” after a few cycles of opening and closing, bypass valve **2016** tends to reach an equilibrium with the plumbing system, whereby bypass valve **2016** stays slightly cracked open, passing just enough hot water to maintain the temperature constantly at its setting. In particular plumbing systems and at certain ambient conditions, this flow is just under that required to maintain a spring loaded check valve cracked continuously open (i.e., check valve **2036**). In such a situation, check valve **2036** chatters with an annoying buzzing sound. To avoid this occurrence, the spring may be removed from check valve **2036**, leaving the check valve poppet free floating. In the event that the hot water is turned full on at a time when bypass valve **2016** is open, thereby lowering the pressure in hot water line **2026** and inducing flow from cold water line **2022** through the open bypass valve **2016** to the hot side, the free floating poppet will quickly close. There is no necessity for a spring to keep check valve **2036** closed prior to the reversal in pressures.

Although not entirely demonstrated in early tests, it is believed that beneficial “toggle” action can be achieved with the thermostatically controlled bypass valve **2016** discussed above. If the motion of actuating element **2054** is made to lag behind the temperature change of the water surrounding it by placing suitable insulation around actuating element **2054** or by partially isolating it from the water, then instead of slowly closing only to reach equilibrium at a low flow without reaching shutoff, the water temperature will rise above the extending temperature of the insulated actuating element **2054** as bypass valve **2016** approaches shutoff, and piston **2080** will then continue to extend as the internal temperature of actuating element **2054** catches up to its higher surrounding temperature, closing bypass valve **2016** completely. It is also believed that an insulated actuating element **2054** will be slow opening, its motion lagging behind the temperature of the surrounding cooling-off water from which it is insulated. When actuating element **2054** finally begins to open the bypass valve **2016** and allow flow, the resulting rising temperature of the surrounding water will again, due to the insulation, not immediately affect it, allowing bypass valve **2016** to stay open longer for a complete cycle of temperature rise. Such an “insulated” effect may also be accomplished by use of a wax mix that is inherently slower, such as one with less powdered copper or other thermally conductive filler. An actuating element **2054** to be installed with insulation can be manufactured with a somewhat lower set point temperature to make up for the lag, allowing whatever bypass valve **2016** closing temperature desired.

An additional benefit of utilizing pump **2032** in system **2018** is that shut-off of a toggle action valve upon attainment of the desired temperature is enhanced by the differential pressure an operating pump **2032** provides. If pump **2032** continues to run as the water at water control valve **2010**, **2012** or **2014** cools down, the pump-produced differential pressure works against re-opening a poppet type bypass valve **2016**. If pump **2032** operates cyclically, powered only a little longer than necessary to get hot water to water control valve **2010**, **2012** or **2014**, it will be “off” before the water at bypass valve **2016** cools down. When the minimum temperature is reached, actuating element **2054** will retract, allowing bias spring **2056** to open bypass valve **2016** without having to fight a pump-produced differential pressure. Bypass flow will begin with the next pump “on” cycle. An additional benefit to the use of either a time-of-day or cyclic timer **2040** is that it improves the operating life of actuating element **2054**. Because use of either timer **2040** causes cyclic temperature changes in bypass valve **2016** (as opposed to maintaining an equilibrium setting wherein temperature is constant and actuating element **2054** barely moves), there is frequent, substantial motion of the piston **2080** in actuating element **2054**. This exercising of actuating element **2054** tends to prevent the build-up of hard water deposits and corrosion on the cylindrical surface of actuator piston **2080** and face of poppet **2078**, which deposits could render bypass valve **2016** inoperable.

Also inside bypass valve **2016** can be an over-travel spring **2058** disposed between the second side **2090** of the actuator body **2084** and a stop, such as retaining mechanism **2062** shown in FIG. **49**, located inside bypass valve **2016** to prevent damage to a fully restrained actuating element **2054** if it were heated above the maximum operating temperature of bypass valve **2016** and to hold actuating element **2054** in place during operation without concern for normal tolerance. Use of over-travel spring **2058**, which is not necessary for spool-type valves, allows movement of actuator body **2084** away from the seated poppet **2078** in the event that temperature rises substantially after poppet **2078** contacts valve seat **2070**. Without this relief, the expanding wax could distort its copper can, destroying the calibrated set point. Over-travel spring **2058** also holds bias spring **2056**, rod member **2076** and actuator body **2084** in place without the need to adjust for the stack-up of axial tolerances. Alternatively, actuating element **2054** can be fixedly placed inside bypass valve **2016** by various mechanisms known in the art, including adhesives and the like. Over-travel spring **2058**, if used, can be held in place by various internal configurations commonly known in the art, such as a molded seat (not shown).

Although there are a great many configurations and brands of water control valves **2010**, **2012** and **2014**, it is believed that there are several generic forms of such valves, such as those described below. The water control valves adaptable for use with bypass valves **2016**, including but not limited to thermostatically controlled bypass valves, include a combination shower/tub valve **2010**, a separate service control valve **2012** and a combination service control valve **2014**. As such, these generic forms of water control valves **2010**, **2012** and **2014** are utilized below to illustrate several different designs that are adaptable for the use of bypass valve **2016** therewith. The following examples are only representative of the types of water control valves which bypass valve **2016** can be used. As is well known in the art, the individual manufacturers have various models of water control valves to incorporate desired features and preferences. The examples are for illustrative purposes only and are not intended to restrict the valves to particular uses, sizes or materials used in the examples.

EXAMPLE 4

Shower/Tub Control Valve with Attached Bypass Valve

As is well known, many homes have a combination shower and tub assembly whereby the same water control valve **2010** is used to control the flow and temperature to the shower and the tub. A selector valve (not shown) is used to select the flow between the shower and the tub. An example shower/tub system is shown as **2034** in FIG. **48**. A similar water control valve to that shown as **2010**, is used for systems comprising only a shower or a tub, with the exception that such valve only has one discharge port (connected to either the shower or the tub). In the shower/tub system **2034**, water distribution valve

2010 with associated bypass valve assembly **2098**, having bypass valve **2016** as described below, distributes water to the shower head assembly **2100** through shower line **2102** and to tub faucet **2104** through tub line **2106**, as shown in FIG. **48**. A flow control valve **2108** is used to control the flow and temperature of water to the shower head assembly **2100** or tub faucet **2104**. Although a single flow control valve **2108** is shown in FIG. **48**, it is understood that some shower, tub and shower/tub flow control valves utilize separate valves for the hot and cold water control (i.e., similar in general configuration to the service control valves discussed below). One of the primary distinguishing characteristics of virtually all shower/tub water control valves, such as **2010**, and single shower or tub water control valves is that they are generally positioned at least partially behind support wall **2110** that forms part of the shower and/or tub enclosure and which is used to support shower head assembly **2100** and tub faucet **2104**. Because access to water control valve **2010** is important for maintenance, repair or replacement of water control valve **2010**, even if positioned entirely behind support wall **2110**, water control valve **2010** is generally placed behind an opening **2112** in support wall **2110** specifically configured for accessing water control valve **2010**. Typically a removable plate **2114**, commonly referred to as an escutcheon plate, is used to cover opening **2112**. To access water control valve **2010** and bypass valve assembly **2098**, plate **2114** is removed and valve **2010** is maintained, repaired or removed through opening **2112** in support wall **2110** and then plate **2114** is reinstalled.

Shower/tub water control valve **2010**, shown in more detail in FIGS. **52** and **53**, is used to illustrate various configurations for providing valve **2010** that is adaptable for use with bypass valve **2016**. The typical water control valve **2010** consists of a valve manifold **2118** having a hot water inlet **2120** that connects to hot water line **2026** to allow hot water to flow through control valve hot passageway **2122** to the inner valve workings, which generally comprise a removable valve cartridge **2123**, inside cartridge cavity or valve interface **2124** of valve manifold **2118**. The typical valve interface **2124** is configured as a cylindrical cavity sized to frictionally receive valve cartridge **2123** therein and to have ports for the inflow of hot and cold water and the discharge of mixed water to shower line **2102** and/or tub line **2106**. Cold water inlet **2126** of valve **2010** connects to cold water line **2022** to allow cold water to flow through control valve cold passageway **2128** to valve cartridge **2123** inside valve interface **2124**. Inside valve interface **2124**, valve cartridge **2123** selectively distributes hot and cold water to shower head assembly **2100** or tub faucet **2104** through shower line **2102** or tub line **2106**, respectively. Water control valve **2010** is modified to be adaptable for use with bypass valve **2016** by adding a single external port **2130** on valve manifold **2118**, an internal hot water bypass passageway **2134**, an internal cold water bypass passageway **2136** and separate hot water bypass port **2138** and cold water bypass port **2140**. In the preferred embodiment, water control valve **2010** has valve manifold **2118** manufactured to include external port **2130**, internal bypass passageways **2134** and **2136** and bypass ports **2138** and **2140**. Although an existing water control valve **2010** can be modified to include these components, it is believed to be much easier and cost effective to include them in the initial manufacturing process than to add them to an existing valve **2010**. Although the bypass valve assembly **2098** is shown affixed to the top of water control valve **2010** in FIG. **48** and in front of water control valve **2010** in FIG. **53**, bypass valve assembly **2098** can be affixed to water control valve **2010** at any place on valve manifold **2118** which is convenient, practical or cost effective. An important aspect of attachment of bypass valve assembly **2098** for use with water control valve **2010** is the ability to access bypass valve assembly **2098** through opening **2112** in support wall **2110** for purposes of maintenance, repair or replacement of bypass valve **2016**.

In the preferred embodiment of water control valve **2010** having external port **2130**, as shown in FIGS. **52** and **53**, bypass valve assembly **2098** comprises a bypass housing **2142** enclosing bypass valve **2016** and water control valve **2010** has a sealing element, such as O-ring **2144**, to seal the connection between bypass housing **2142** and valve manifold **2118** at external port **2130**. To prevent cross-flow between bypass ports **2138** and **2140**, and therefore bypassing of bypass valve **2016**, at least one of these ports should have a sealing member, such as an O-ring or other sealing member (not shown). Bypass valve input line **2146** connects hot water bypass passageway **2134** with bypass valve inlet **2046** and bypass valve output line **2148** connects bypass valve outlet **2048** to cold water bypass passageway **2136**. Connecting elements **2150** of the type known by those in the industry, such as clips, unions, bolts, threaded connections and the like, are used to connect bypass valve input line **2146** with hot water bypass passageway **2134** and bypass valve output line **2148** with cold water bypass passageway **2136**. Also in the preferred embodiment, control valve **2010** includes screen **2149** positioned at or near the entrance to hot water bypass passageway **2134**. Screen **2149** should be installed in a manner that allows it to be self-cleaning. As is known in the art, this can be accomplished by placing screen **2149** in water control valve **2010** such that the main flow of hot water from hot water inlet **2120** will flow across the face of screen **2149** when "hot" water is flowing through water control valve **2010** to discharge through shower line **2102** or tub line **2106**. When water is being bypassed, screen **2149** will filter out any debris that could otherwise plug or damage bypass valve **2016**. The materials collected on screen **2149** will then be washed away through water control valve **2010** when hot water flows through water control valve **2010** to shower line **2102** or tub line **2106** (i.e., the discharge from water control valve **2010**).

When installed with water control valve **2010**, as shown in FIG. **53**, bypass valve assembly **2098** is sealably and rigidly connected to and supported by valve manifold **2118** in shower system **2034**. When the water in hot water line **2026** is no longer at the desired temperature (i.e., the temperature lowers to be tepid or cool), bypass valve **2016** opens to bypass the non-hot water around water control valve **2010** by diverting water flow from hot water line **2026** through hot water bypass passageway **2134** and hot water bypass port **2138** into bypass valve input line **2146** through bypass valve **2016** to bypass output line **2148**, cold water bypass port **2140**, cold water bypass passageway **2136** and then to cold water line **2022**. In the preferred embodiment, pump **2032** provides the pressure in hot water line **2026** for the necessary bypassing. The bypassing of this cool or cold water in hot water line **2026** will continue until the temperature in hot water line **2026** is at the desired temperature. At that time, bypass valve **2016** will close and hot water (as desired) will be at the water control valve **2010** ready for selection by flow control valve **2108** and distribution to shower head assembly **2100** or tub faucet **2104**.

As discussed above, bypass valve **2016** inside of bypass valve assembly **2098** can be of the thermostatically controlled, electric solenoid, manually operated or other type of bypass valve. The preferred embodiment utilizes a thermostatically controlled bypass valve, such as that described above with the wax motor as the thermal actuating element **54**, due to its ability to automatically bypass cold or tepid water until the temperature of the water in hot water line **2026** at control valve **2010** is at the desired temperature. Water control valve **2010** can be provided with bypass assembly **2098** already connected to valve manifold **2118** or water control valve **2010** can be sold as an optional unit having a removable cap element (not shown) closing external port **2130** to seal against sealing element **2144** and sealing member **2145** for when bypass assembly **2098** is not in use with water control valve **2010**. In yet another configuration, bypass assembly **2098** is fixedly attached to or manufactured with valve manifold **2118** such that water control valve **2010** and bypass assembly **2098** are a single unit. This configuration would eliminate the need for sealing element **2144** and sealing member **2145**, such as the O-rings shown in FIGS. **52** and **53**. While the embodiment of the single bypass assembly **2098** and water control valve **2010** as a single unit has the advantage of eliminating a seal and, as a result, a potential leak source, utilizing bypass assembly **2098** as a separate unit has the advantage of allowing the same water control valve **2010** to be sold with or without bypass valve **2016** and allowing the user to maintains repair or replace bypass valve **2016** separate from water control valve **2010**. As stated above, whether the bypass assembly **2098** is sold integral with water control valve **2010** or as single unit requiring sealing element **2144**, it should be configured to be accessible to the user through opening **2112** in support wall **2110**.

Another configuration for a water control valve **2010** having a rigidly attached bypass valve **2016** is shown in FIGS. **54** and **55** and an alternative bypass valve **2016** particularly configured for use with such a water control valve **2010** is shown in FIG. **56**. In this configuration, instead of the single external port **2130** utilizing one atmospheric sealing element **2144**, the hot **2138** and cold **2140** water bypass ports connect directly to the respective input **2146** and output **2148** lines of bypass valve **2016** with atmospheric seals at each such connection. As with the above water control valve **2010**, valve manifold **2118** of this configuration is also manufactured to have or modified to have hot water bypass passageway **2134** interconnecting hot water inlet **2120** and hot water bypass port **2138** and cold water bypass passageway **2136** interconnecting cold water inlet **2126** and cold water bypass port **2140**. As shown in FIG. **54**, bypass assembly **2098**, configured generally as shown in FIG. **53**, connects to directly to the hot **2138** and cold **2140** water input ports with the bypass valve **2016** disposed inside bypass housing **2142** to bypass water around water control valve **2010**. As shown in FIG. **55**, hot water bypass port **2138** has sealing element, such as O-ring **2151**, to sealably connect port **2138** with the input line **2146** to bypass valve **2016** and cold water bypass port **2140** has sealing element, such as O-ring **2152**, to sealably connect port **2140** with the output line **2148** from bypass valve **2016**. As also shown in FIG. **55**, valve manifold **2118** can include enlarged portion **2154** for mounting bypass assembly **2098** or bypass valve **2016** against valve manifold **2118**. As shown in FIG. **54** and explained above, screen **2149** can be placed at or near the entrance to hot water bypass passageway to filter debris and be self-cleaning.

As with the previous embodiment of water control valve **2010**, bypass valve **2016** can be of the thermostatically controlled, electric solenoid, manually operated or other type of bypass valve. Instead of utilizing bypass assembly **2098**, as shown in FIG. **54**, valve body **2044** of bypass valve **2016** can be modified to mount directly to hot **2138** and cold **2140** bypass ports. One embodiment of such a bypass valve **2016** is shown in FIG. **56**. This embodiment comprises a generally U-shaped bypass valve body **2044** with valve inlet **2046** and valve outlet **2048** configured to sealably mount to hot water bypass port **2138** and cold water bypass port **2140**, respectively. This embodiment, which utilizes the thermostatically controlled components discussed in detail above, requires bypass valve inlet **2046** and bypass valve outlet **2048** to be spaced in corresponding relationship to hot water bypass port **2138** and cold water bypass port **2140**.

When installed, bypass valve assembly **2098** or bypass valve **2016** is sealably and rigidly connected to and supported by valve manifold **2118** in shower system **2034**. When the water in hot water line **2026** is no longer at the desired temperature (i.e., the temperature lowers to be tepid or cool), bypass valve **2016** opens to bypass the non-hot water around water control valve **2010** by diverting water flow from hot water line **2026** at hot water inlet **2120** through hot water bypass passageway **2134** and hot water bypass port **2138** into bypass valve inlet **2046** then through bypass valve **2016** to bypass valve output **2048**, cold water bypass port **2140**, cold water bypass passageway **2136** and then to cold water line **2022** at cold water inlet **2126**. In the preferred embodiment, pump **2032** provides the pressure in hot water line **2026** for the necessary bypassing. The bypassing of this cool or cold water in hot water line **2026** will continue until the temperature in hot water line **2026** is at the desired temperature. At that time, bypass valve **2016** will close and hot water (as desired) will be at the water control valve **2010** ready for selection by flow control valve **2108** and distribution to shower head assembly **2100** or tub faucet **2104**.

As with the previous embodiment, water control valve **2010** can be provided with bypass assembly **2098** or bypass valve **2016** already connected to valve manifold **2118** or water control valve **2010** can be sold with removable cap elements (not shown) that sealably close hot **2138** and cold **2140** bypass ports so that bypass assembly **2098** or bypass valve **2016** can be provided as an optional unit. In yet another alternative configuration, bypass assembly **2098** or bypass valve **2016** is fixedly attached to or manufactured with valve manifold **2118** such that water control valve **2010** and bypass assembly **2098** or bypass valve **2016** are a single, integral unit. This configuration eliminates the need for sealing elements **2150** and **2152**. As stated above, whether the bypass assembly **2098** or bypass valve **2016** is sold integral with water control valve **2010** or as separate units requiring sealing elements **2150** and **2152**, it should be configured to be accessible to the user through opening **2112** in support wall **2110**.

Another embodiment of a water control valve **2010** having an attached bypass valve **2016** is shown in FIG. **57**. In this embodiment, bypass valve inlet **2046** is connected to hot water bypass port **2138** by first tubular line **2156** and bypass valve outlet **2048** is connected to cold water bypass port **2140** by second tubular line **2158**. As shown in FIG. **57**, hot **2138** and cold **2140** bypass ports can connect to hot water inlet **2120** and cold water inlet **2126**, respectively, through bypass passageways **2134** and **2136** (shown in other figures) that extend through the wall of valve manifold **2118** at hot **2120** and cold **2126** water inlets. Alternatively, hot **2138** and cold **2140** bypass ports can be positioned at other places on valve manifold **2118**, such as shown in FIGS. **54** and **55**, with hot **2134** and cold **2136** bypass passageways interconnecting bypass ports **2138** and **2140** with inlets **2120** and **2126**. In the preferred embodiment, first **2156** and second **2158** tubular lines are flexible tubular members such as the flexible hose commonly utilized in plumbing facilities. Alternatively, first **2156** and second **2158** tubular lines can be semi-rigid or rigid tubing, such as that made out of copper, stainless steel, fiberglass or various composite materials. As known by those skilled in the art, connections between hot water bypass port **2138** and first tubular line **2156** and between first tubular line

2156 and bypass valve inlet 2046, as well as those on the cold water side of control valve 2010, should be sealed to prevent leakage of water.

In the attached configuration of this embodiment, bypass valve 2016 is affixed to valve manifold 2118 by one or more connecting elements 2160 each having one or more attachment mechanisms 2162, such as a screw, bolt, rivet or etc. Connecting elements 2160 can be an integral part of bypass valve body 2044, as shown in FIG. 57, or they can be separate elements used to attach one piece onto another piece, such as a U-shaped strap. In this manner, bypass valve 2016 is affixed to water control valve 2010 and accessible with it through opening 2112 in support wall 2110. As above, although the preferred bypass valve 2016 is the thermostatically controlled bypass valve previously described, bypass valve 2016 can be the needle valve, electric solenoid or manually operated type of bypass valves. In addition, bypass valve 2016 can be sold integral with tubular lines 2156 and 2158 or the control valve 2010 and bypass valve 2016 can be sold as a single integral unit to eliminate the necessary sealing elements between the various connections. In addition, as previously described, control valve 2010 can be sold with one or more cap elements (not shown) to seal ports 2138 and 2140 so that bypass valve 2016 and associated tubular lines 2156 and 2158 can be sold separately.

When installed, bypass valve 2016 is sealably and rigidly connected to and supported by valve manifold 2118 in shower system 2034 by use of connecting element 2160 and attachment mechanisms 2162. When the water in hot water line 2026 is no longer at the desired temperature (i.e., the temperature lowers to be tepid or cool), bypass valve 2016 opens to bypass the non-hot water around water control valve 2010 by diverting water flow from hot water line 2026 at hot water inlet 2120 through hot water bypass passageway 2134, hot water bypass port 2138 and first tubular line 2156 into bypass valve inlet 2046 through bypass valve 2016 to bypass valve output 2048, second tubular line 2158, cold water bypass port 2140, cold water bypass passageway 2136 and then to cold water line 2022 at cold water inlet 2126. In the preferred embodiment, pump 2032 provides the pressure in hot water line 2026 for the necessary bypassing. The bypassing of this cool or cold water in hot water line 2026 will continue until the temperature in hot water line 2026 is at the desired temperature. At that time, bypass valve 2016 will close and hot water (as desired) will be at the water control valve 2010 ready for selection by flow control valve 2108 and distribution to shower head assembly 2100 or tub faucet 2104.

Yet another embodiment of a water control valve 2010 having an attached bypass valve 2016 is shown in FIG. 58. In this embodiment, a standard water control valve 2010 is utilized with a first bypass connector 2164 and second bypass connector 2166 that connect to bypass valve 2016. As shown in FIG. 58, bypass connector 2164 is disposed between hot water line 2026 and hot water inlet 2120 and bypass connector 2166 is disposed between cold water line 2022 and cold water inlet 2126. Bypass connectors 2164 and 2166 can be of the standard tee (as shown) or three-way elbow type of connector having an inlet 2168 and control valve outlet 2170 to connect to control valve 2010. Bypass connector 2164 has bypass outlet 2172 and bypass connector 2166 has bypass inlet 2174, configured as shown in FIG. 58, to connect to bypass valve 2016. As with the previous embodiment, the connection between first bypass connector 2164 and hot water inlet 2120 and between second bypass connector 2166 and cold water inlet 2126 can be by flexible or rigid tubular lines 2156 and 2158, respectively. The connections between first 2164 and second 2166 bypass connectors and control valve 2010 and bypass valve 2016 should be by sealable connectors so as to prevent leakage at such connections. As discussed in more detail above, bypass connectors 2164 and 2166, tubular lines 2156 and 2158 and bypass valve 2016 can be provided as a single, integral unit and bypass connectors 2164 and 2166 can be provided with cap elements (not shown) to close off bypass outlet 2172 when bypass valve 2016 is not used or removed from service through opening 2112 in support wall 2110 for maintenance, repair or replacement. As also discussed above, water control valve 2010 can be provided with screen 2149 to filter debris before it gets to bypass valve 2016. Placing screen 2149 at or near the entrance to bypass outlet 2172, as shown, will allow screen 2149 to be self-cleaning by washing the face of screen 2149 when hot water is flowing through water control valve 2010. As with the embodiment shown in FIG. 57, bypass valve 2016 is affixed to valve manifold 2118 so that it is supported from valve manifold 2118. FIG. 58 shows the use of a U-shaped strap as the connecting element 2160 held in place against valve manifold 2118 by a pair of attachment mechanisms 2162. With the water control valve 2010 in the closed position, any cold or tepid water in hot water line 2026 will be diverted around water control valve 2010 through first bypass connector 2164 and first tubular line 2156 to bypass valve 2016 and then to second tubular line 2158 and second bypass connector 2166 to cold water line 2022. As soon as the water being bypassed reaches the desired temperature, bypass valve 2016 will close so that hot water, at the desired temperature, will be at control valve 2010 for use at shower head assembly 2100 or tub faucet 2104.

EXAMPLE 5

Shower/Tub Control Valve with Adjacent Bypass Valve

In an exemplary embodiment, where bypass valve 2016 is adjacent to (i.e., but not physically attached to or supported by) water control valve 2010, shown in FIGS. 59 and 60, bypass valve 2016 is directly supported by first tubular line 2156 and second tubular line 2158. FIG. 59 illustrates a configuration similar to that shown in FIG. 57 and discussed above except for there is no connecting element 2160 or attachment mechanism 2162 to affix bypass valve 2016 to valve manifold 2118. Likewise, FIG. 60 illustrates a configuration similar to that shown in FIG. 58 and discussed above except there is no connecting element 2160 or attachment mechanism 2162 for affixing bypass valve 2016 to valve manifold 2118. Depending on the flexibility of first tubular line 2156 and second tubular line 2158, bypass valve 2016 hangs freely from their connection to ports 2138 and 2140 on water control valve 2010 or from first 2164 and second 2166 bypass connectors. The principal benefit of the adjacent configuration is that there is no need for connecting element 2160 and any mechanism to attach it to valve manifold 2118 and it may be easier to retrofit existing water control valve 2010 installations by the necessary components. This is particularly true with regard to the embodiment shown in FIG. 60 that only requires the addition of first 2164 and second 2166 bypass connectors between an existing water control valve 2010 and the existing hot water line 2026 and cold water line 2022. As discussed above, these embodiments can also include self-cleaning screen 2149. Instead of utilizing water control valve 2016, the various embodiments set forth herein, including those discussed above, can utilize bypass valve assembly 2098 having bypass valve 2016 disposed therein.

In the embodiment of water control valve **2010** shown in FIG. **61**, valve manifold **2118** is configured to have an external valve cartridge **2300** that is attached to valve manifold **2118** at manifold interface **2302**. The primary difference between the embodiment shown in FIG. **61** and those previously described is that valve interface **2124** is configured in the form of a generally cylindrical cavity adaptable for receiving valve cartridge **2123** therein. Instead of utilizing valve cartridge **2123** of the previous embodiments, which interfaces with the cylindrical cartridge cavity (i.e., valve interface **2124**) inside of valve manifold **2118**, the embodiment of FIG. **61** utilizes valve cartridge **2300** that removably abuts flat interface **2302**, which is configured to have ports for the flow of hot and cold water to valve cartridge **2300** and the discharge of mixed water to shower line **2102** and/or tub line **2106**. Generally, valve cartridge **2300** attaches to valve interface **2302** by way of one or more attachment mechanisms, such as screws **2304**. With regard to the use of bypass valve **2016**, the embodiment shown in FIG. **61** is similar in concept to that shown in FIG. **60** and described above. Typically, valve manifold **2118** of this configuration has hot water threaded end **2306** and cold water threaded end **2308** for connection to the supply of hot water and cold water, respectively. As with the previous embodiment, first tubular line **2156** interconnects hot water bypass port **2138** on hot water inlet **2120** to bypass valve inlet **2046** on bypass valve **2016** and second tubular line **2158** interconnects bypass valve outlet **2048** to cold water bypass port **2140** on cold water inlet **2126**. As discussed above, appropriate sealing members need to be utilized to prevent leakage and self-cleaning screen **2149** can be used to prevent debris and other matter from entering bypass valve **2016**. Although the embodiment shown in FIG. **61** is similar to that of FIG. **61**, it is known and understood that the various embodiments can also be adapted for use with the valve manifold **2118** and cartridge **2300** combination of FIG. **61**.

EXAMPLE 6

Service Control Valve

In the embodiment wherein bypass valve **2016** is included with the water control valve **2010**, shown as water control valves **2012** and **2014** in FIGS. **61** through **64**, bypass valve **2016** is integrated with or appended to a pair of individual water control valves **2012**, also known as angle stops, or incorporated with a combination water control valve **2014**. These types of valves are commonly referred to as service valves or non-working valves because they are not operated so as to be frequently moved from the opened to closed positions. Service valves are primarily utilized to connect to washing machines, sinks or faucets on sinks, dishwashing machines and the like apparatuses. Normally, service valves are left in the open position, only being closed to repair or replace the apparatus. In the open position, water is allowed to flow freely to the apparatus, with the apparatus itself having a control valve such as an electrically controlled solenoid valve incorporated therein to control the amount of cold or hot water allowed into the apparatus. Unfortunately, no provision is generally made for the fact that hot water may not actually be at the service valve, due to the cooling effect discussed above, when the apparatus's control valve opens to allow in "hot" water to the apparatus. As such, undesirably cold or tepid water may be utilized in the apparatus to clean clothes or dishes or perform other operations best done in hot water.

As shown in FIGS. **62** and **63**, in use water control valve **2012** comprises a pair of independent water control valves, hot water valve **2012***a* and cold water **2012***b* to supply hot or cold water to the apparatus **2176** (shown as a washing machine in FIG. **62** illustrating a system **2178** utilizing water control valve **2012**). Generally, other than the water that flows through them, water control valves **2012***a* and **2012***b* are the same and, when referenced herein collectively as water control valve **2012**, is meant to refer to both hot water valve **2012***a* and cold water valve **2012***b*. Water control valve **2012** has valve manifold **2180** enclosing the inner workings (not shown) of water control valve **2012** that are operated by an operating mechanism, such as handle **2182**, to open or close valve **2012** to independently allow water, hot or cold depending on which water valve **2012***a* or **2012***b* is operated, to flow to apparatus **2176** through hot water hose **2184** or cold water hose **2186**, respectively. Generally, water control valve **2012** has an inlet **2188** with a connection suitable to connect to an end of either hot water line **2026** or cold water line **2022**, depending on which valve **2012***a* or **2012***b* is referenced, extending through wall **2190** and past cover plate **2192**. Water control valve **2012** also has a first valve outlet **2194**, generally configured with a male connection suitable for connecting to female coupling **2196** on the end of hose **2184** or **2186**.

Each of water control valves **2012***a* and **2012***b* are modified to include a hot water second outlet **2198** and cold water second outlet **200**, respectively, to connect to bypass valve **2016** for bypassing cold or tepid water around valves **2012***a* and **2012***b* so as to maintain hot water at water control valve **2012***a* ready for use by apparatus **2176**. Although the preferred bypass valve **2016** is a thermostatically controlled bypass valve, as described above, bypass valve **2016** can be the needle, electric solenoid, manually operated or other type of bypass valve. As also discussed above, screen **2149** can be utilized to screen debris before it gets to bypass valve **2016** and be positioned at or near the entrance to hot water second outlet **2198** to be self-cleaning when hot water is not flowing to apparatus **2176**. Depending on the distance between water valves **2012***a* and **2012***b*, one or more tubular extension members **2202** will be necessary to connect hot water second outlet **2198** to bypass valve inlet **2046** and/or to connect bypass outlet **2048** to cold water second outlet **2200**. Alternatively, bypass valve **2016** can have valve inlet **2046** and valve outlet **2048** which extend to interconnect water control valves **2012***a* and **2012***b* to eliminate the additional connections necessary for extension members **2202**, although this could limit flexibility with regard to the distance between valves **2012***a* and **2012***b*. Use of one or more extension members **2202**, such as the two shown in FIG. **63**, provide increased flexibility with regard to the spacing of valves **2012***a* and **2012***b*. In yet another alternative, water control valves **2012***a* and **2012***b* could be manufactured integral with bypass valve **2016**, thereby completely eliminating the need for separate tubular extension members **2202** and any connections to second valve outlets **2198** and **2200**. When installed, bypass valve **2016** is sealably and rigidly connected and supported adjacent to water control valves **2012***a* and **2012***b* in system **2178**. When the water in hot water line **2026** is no longer at the desired temperature (i.e., the temperature lowers to be tepid or cool), bypass valve **2016** opens to bypass the non-hot water around water control valves **2012***a* by diverting water flow from hot water line **2026** at hot water second outlet **2198** through extension member **2202**, if used, into bypass valve inlet **2046** then through bypass valve **2016** to bypass valve output **2048** and then to cold water line **2022** at cold water second outlet **2200**. In the preferred embodiment, pump **2032** provides the pressure in hot water line **2026** for the necessary bypassing. The bypassing of this cool or cold water in hot water line **2026** will continue until the temperature in hot water line **2026** is at the desired temperature. At that time, bypass valve **2016** will close and hot water (as desired) will be at the water control valve **2012***b* ready for selection by the flow control valve at or inside apparatus **2176**.

As an alternative, system **2178** can be modified to utilize a pair of saddle valves **2204**, such self tapping variety, to establish a connection between water control valves **2012***a* and **2012***b* for connection to bypass valve **2016**, as shown in FIG. **64**. Saddle valves **204** can be located in front of wall **2190**, as shown, for ease of access for repair, maintenance or replacement of bypass valve **2016** or they can be located behind wall **2190**. Alternatively, not shown, saddle valves **2204** can attach to and interconnect hot water hose **2184** and cold water hose **2186** to bypass cold or tepid water through bypass valve **2016**. In yet another configuration, shown in FIG. **65**, system **2178** can utilize a first bypass connector **2206** connected to water control valve **2012***a* and second bypass connector **2208** connected to water control valve **2012***b* that connect to bypass valve **2016**. As shown, bypass connector **2206** is disposed between outlet **2194** on valve **2012***a* and hose coupling **2196** on hot water hose **2184**, and bypass connector **2208** is disposed between outlet **2194** on valve **2012***b* and hose coupling **2196** on cold water hose **2186** to bypass cold or tepid water from hot water line **2026** to cold water line **2022**. Bypass connectors **2206** and **2208** can be of the standard tee type (as shown) or three-way elbow type of connector having an inlet **2210** and hose outlet **2212** to connect to control valves **2012***a* and **2012***b* and hoses **2184** and **2186**. Bypass connector **2206** has bypass outlet **2214** and bypass connector **2208** has bypass inlet **2215**, configured as shown in FIG. **65**, to connect to bypass valve **2016**. The connection between first bypass connector **2206** and bypass valve inlet **2046** on bypass valve **2016** and between second bypass connector **2208** and bypass valve outlet **2048** can be by flexible or rigid tubular lines **2216** and **2218**, respectively. The connections between first **2206** and second **2208** bypass connectors and control valves **2012***a* and **2012***b* and bypass valve **2016** should be by sealable connectors so as to prevent leakage at such connections. As discussed in more detail above, bypass connectors **2206** and **2208**, tubular lines **2216** and **2218** and bypass valve **2016** can be provided as a single, integral unit and bypass connectors **2206** and **2208** can be provided with cap elements (not shown) to close off bypass outlets **2214** when bypass valve **2016** is not used or removed from service for maintenance, repair or replacement.

Another embodiment of a water control valve **2014** with an included bypass valve **2016** is shown in FIG. **66**. In this embodiment, the hot and cold water service valves are joined together in a single unit having a valve manifold **2219** with a hot water component **2220** having a hot water inlet **2222** and hot water outlet **2224** and a cold water component **2226** having a cold water inlet **2228** and cold water outlet **2230**. Hot water component **2220** and cold water component **2226** of water control valve **2014** are joined by a tubular section **2232** enclosing the inner workings (not shown) of control valve **2014** that are operated by an operating mechanism, such as lever **2234** (could be a handle, dial, switch or other like mechanisms). When lever **2234** is moved to the "on" position, the inner workings of valve **2014**, which can be of the ball valve type, operate to open the connection between hot water inlet **2222** and hot water outlet **2224** to allow hot water to flow through hot water chamber **2236** to apparatus **2176** through a hose or other tubular member (such as hose **2184** with a female coupling **2196** thereon) connected to hot water outlet **2224**. Concurrently therewith, the connection between cold water inlet **2228** and cold water outlet **2230** opens to allow cold water to flow through cold water chamber **2238** to apparatus **2176** through a hose or other tubular member connected to cold water outlet **2230**. When lever **2234** is moved to the "off" position, valve **2014** closes to prevent hot and cold water from flowing to apparatus **2176**. For water control valve **2014** adaptable for use to bypass cold or tepid water, bypass valve **2016** is incorporated within tubular section **2232** such that tubular line **2216** interconnects hot water chamber **2236** with bypass valve inlet **2046** and tubular line **2218** interconnects bypass valve outlet **2048** with cold water chamber **2238**. Screen **2149** can be placed at or near the entrance to tubular section **2232** to filter debris from the bypassed water and be self-cleaning when water is not being bypassed. As above, the preferred bypass valve **2016** is a thermostatically controlled bypass valve, such as the thermostatically controlled bypass valve described above, bypass valve **2016** can be the needle, electric solenoid or manually operated type of bypass valve. With bypass valve **2016** installed and water control valve **2014** in the "on" or open position, any cold or tepid water in hot water line **2026** at hot water component **2220** will be bypassed through tubular section **2232** to cold water component **2226** and to cold water line **2022** so as to maintain hot water available at hot water component **2220**.

With regard to the use of a thermostatically controlled bypass valve **2016** having the components shown in FIGS. **49** through **51** and described in the accompanying text, the operation of the bypass valve **2016** is summarized on the chart shown as FIG. **22**. The chart of FIG. **22** summarizes the results of the twenty combinations of conditions (pump on/pump off; hot water line hot/hot water line cooled off; hot water valve fully open, closed or between; cold water valve fully open, closed or between) that are applicable to the operation of bypass valve **2016**. The operating modes IVB, IVC, IVD, IIIB, & IIID are summarized detailed in the immediately following text. The operation of the remaining fifteen modes are relatively more obvious, and may be understood from the abbreviated indications in the outline summarizing FIG. **22**. Starting with the set "off" hours (normal sleeping time, and daytime when no one is usually at home) pump **2032** will not be powered. Everything will be just as if there were no pump **2032** and no bypass valve **2016** in use with water control valves **2010**, **2012** or **2014** (i.e., both the cold and hot water lines will be at the same city water pressure). The water in hot water line **2026** and at bypass valve **2016** will have cooled off during the long interim since the last use of hot water. The reduced water temperature at bypass valve **2016** results in "retraction" of rod member **2076** of the thermally sensitive actuating element **2054**. The force of bias spring **2056** pushing against flange **2082** on rod member **2076** will push it back away from valve seat **2068**, opening bypass valve **2016** for recirculation. Although the thermal actuating element **2054** is open, with pump **2032** not running, no circulation flow results, as the hot **2026** and cold **2022** water lines are at the same pressure. This is the mode indicated as IVB in the outline on FIG. **22**. If the cold water valve at water control valve **2010**, **2012** or **2014** is opened with thermal actuating element **2054** open as in mode IVB above, pressure in cold water line **2022** to the cold water side of water control valve **2010**, **2012** or **2014** will drop below the pressure in hot water line **2026**. This differential pressure will siphon tepid water away from the hot side to the cold side, which is the mode indicated as IVD in the outline on FIG. **22**. The recirculation of the "hot" water will end when the tepid water is exhausted from the hot water line **2026** and the rising temperature of the incoming "hot" water causes actuating element **2054** to close.

If the hot water side of water control valve **2010**, **2012** or **2014** is turned on with actuating element **2054** open as in mode IVB above, pressure in hot water line **2026** will drop below the pressure in cold water line **2022**. This differential pressure, higher on the cold side, will load check valve **2064** in the "closed" direction allowing no cross flow. This is mode IVC in the outline on FIG. **22**. In this mode, with hot water line **2026** cooled and pump **2032** off, a good deal of cooled-off water will have to be run just as if bypass valve **2016** were not installed), to get hot water, at which time actuating element **2054** will close without effect, and without notice by the user. With actuating element **2054** open and hot water line **2026** cooled-off as in mode IVB above, at the preset time of day (or when the cyclic timer trips the next "on" cycle) pump **2032** turns on, pressurizing the water in hot water line **2026**. Pump pressure on the hot side of water control valves **2010**, **2012** or **2014** results in flow through the open actuating element **2054**, thereby pressurizing and deflecting check valve **2064** poppet away from its seat to an open position. Cooled-off water at the boosted pressure will thus circulate from the hot line **2026** through actuating element **2054** and check valve **2064** to the lower pressure cold water line **2022** and back to water heater **2024**. This is the primary "working mode" of the bypass valve **2016** and is the mode indicated as IIIb in the outline on FIG. **22**. If the cold water valve is turned on during the conditions indicated in mode IIIB above (i.e., pump **2032** operating, hot water line **2026** cooled off, and the hot water valve at water control valve **2010**, **2012** or **2014** turned off) and while the desired recirculation is occurring, mode IIID will occur. A pressure drop in the cold water line **2022** due to cold water flow creates a pressure differential across valve **2016** in addition to the differential created by pump **2032**. This allows tepid water to more rapidly bypass to cold water line **2022**. When the tepid water is exhausted from hot water line **2026**, actuating element **2054** will close, ending recirculation.

While there is shown and described herein certain specific alternative forms of the invention, it will be readily apparent to those skilled in the art that the invention is not so limited, but is susceptible to various modifications and rearrangements in design and materials without departing from the spirit and scope of the invention. In particular, it should be noted that the present invention is subject to modification with regard to the dimensional relationships set forth herein and modifications in assembly, materials, size, shape, and use.

What is claimed is:

1. A water control valve assembly, comprising:

a valve manifold having a one-piece unitary body including a plurality of openings, the plurality of openings defining a hot water port, a cold water port, and a discharge port, the body of the valve manifold having a mixing chamber in an interior of the body, the hot water port, cold water port and discharge port being open to the mixing chamber where water from a supply of hot water and a supply of cold water connected to the hot water port and cold water port, respectively, is mixed in the mixing chamber and discharged from the mixing chamber into the discharge port;

a water control element at least partially received in the mixing chamber of the body for controlling the flow of water from the mixing chamber to the discharge port of the valve manifold; and

a bypass valve in fluid communication with the valve manifold, the bypass valve having a bypass valve housing with a bypass passageway therein, the bypass valve being positioned on an exterior of the valve manifold body, the bypass valve configured to bypass water from the supply of hot water to a bypass line.

2. A water control valve assembly in accordance with claim **1**, wherein the bypass valve housing is formed integral with the valve manifold.

3. A water control valve assembly in accordance with claim **1**, wherein the bypass valve housing is sealably and rigidly attached to the outer perimeter of the valve manifold, the bypass passageway being coupled to one of the plurality of openings in the outer perimeter of the body.

4. A water control valve assembly in accordance with claim **1**, wherein the bypass valve includes a thermal actuator.

5. A water control valve assembly in accordance with claim **1**, wherein the bypass valve housing has a hot water inlet port and a bypass port, the hot water inlet port being in fluid communication with the supply of hot water and the bypass port being in fluid communication with the bypass line.

6. A water control valve assembly in accordance with claim **1**, wherein the plurality of openings of the valve manifold includes a first bypass opening in fluid communication with the hot water port and a second bypass opening in fluid communication with the bypass line, the bypass valve housing being mounted to the body, the bypass valve housing having a hot water inlet and a bypass outlet, the bypass valve further comprising a first bypass passageway extending between, and fluidly coupling, the hot water inlet and the first bypass opening, the bypass valve further comprising a second bypass passageway extending between, and fluidly coupling, the bypass outlet and the second bypass opening.

7. A water control valve assembly in accordance with claim **1**, wherein the bypass line is one of a dedicated hot water return line and a cold water supply line.

8. A water control valve assembly in accordance with claim **1**, wherein the valve manifold includes a hot water inlet and a cold water inlet, the bypass valve housing having a hot water port and a cold water port, the water control valve assembly further comprising:

a first bypass connector connected between the hot water inlet and a hot water supply line and a second bypass connector connected between the cold water inlet and a cold water supply line; and

a first tubular line between the first bypass connector and the hot water port and a second tubular line between the second bypass connector and the cold water port, wherein the hot water port is in fluid communication with the water channeled through the first bypass connector and the cold water port being in fluid communication with the water channeled through the second bypass connector.

9. A water control valve assembly in accordance with claim **1**, further comprising:

a hot water bypass passage fluidly connecting the supply of hot water and the bypass valve; and

a bypass line passage fluidly connecting the bypass line and the bypass valve.

10. A water control valve assembly in accordance with claim **1**, wherein the water control element is at least partially received in the mixing chamber, the water control element controlling an amount of water channeled to the mixing chamber from at least one of the supply of hot water and the supply of cold water.

11. A water control valve assembly in accordance with claim **1**, wherein the bypass valve opens to permit a flow of water from the supply of hot water to the bypass line based on an activation condition.

12. A water control valve assembly in accordance with claim **1**, wherein the bypass valve is thermostatically controlled and controls the flow of water from the supply of hot water to the bypass line until the temperature of the water at the mixing chamber is at a preset level.

13. A water control valve assembly in accordance with claim **1**, wherein the bypass valve includes a thermal actuator received within a bypass passageway, the thermal actuator having an actuating body and a rod member, the rod member configured to retract and extend to open and close the bypass passageway based on a temperature of the water.

14. A water control valve assembly in accordance with claim **1**, wherein the water control element is a valve cartridge.

15. A water control valve assembly in accordance with claim **1**, further comprising multiple water control elements for controlling the flow of water to multiple discharge ports.

16. A water control valve assembly in accordance with claim **1**, wherein the bypass valve housing has a connecting element extending therefrom, the connecting element being coupled to the body of the valve manifold by an attachment mechanism such that the bypass valve housing is rigidly connected to and supported by the body of the valve manifold.

17. A water control valve assembly in accordance with claim **1**, wherein the valve manifold is configured for use as a shower control valve, the body of the valve manifold has a compact size and shape receiving the water control valve therein, the discharge port being coupled to a shower line configured to deliver water to a shower faucet.

18. A water control valve assembly in accordance with claim **1**, wherein the valve manifold is configured for use as a tub control valve, the plurality of openings defining a second discharge port being coupled to a tub line configured to deliver water to a tub faucet.

19. A water control valve assembly in accordance with claim **1**, wherein the plurality of openings defines a bypass port configured to be in fluid communication with the bypass valve, the water control valve further comprising a plug configured to plug the bypass port, wherein the bypass valve is selectively coupled to the valve manifold such that the valve manifold is operable with or without the bypass valve, when the plug seals the bypass port, the valve manifold is operated in a non-bypass mode of operation, when the plug is removed and the bypass valve is coupled to the valve manifold, the valve manifold is operated in a bypass mode of operation.

20. A water control valve assembly in accordance with claim **1**, wherein the bypass valve changes state when heated and when cooled to block and permit the recirculating flow of water based on a temperature of the water.

21. A water control valve assembly in accordance with claim **1**, wherein the bypass valve changes state through a snap action when heated and when cooled to block and permit the recirculating flow based on a temperature of the bypass valve.

22. A water control valve assembly in accordance with claim **1**, wherein the bypass valve constitutes a bimetallic member.

23. A water control valve assembly in accordance with claim **22**, wherein the bimetallic member constitutes a bimetallic spring.

24. A water control valve assembly in accordance with claim **1**, wherein the body includes a first threaded fitting and a second threaded fitting, the hot water port being arranged at a distal end of the first threaded fitting for connection to a hot water supply line, the cold water port being arranged at a distal end of the second threaded fitting for connection to a cold water supply line.

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